Using Smart Glasses in Medical Emergency Situations, a Qualitative Pilot Study

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Abstract— **Medical emergency situations happening outside a hospital require a large range of competencies from safe transportation of a patient to his/her medical stabilization before the transport. Paramedics are trained to face such situations and can handle most of them very well. Some situations need precise skills and knowledge that are very common in a hospital setting but less in prehospital settings. Currently, paramedics have to work mostly disconnected from hospital skills and knowledge. This may lead to delay of patient care and loss of information from the accident site to the hospital.**

In this paper, we present a pilot study assessing a new communication platform for prehospital care. With this platform, paramedics can access medical knowledge from hospital specialists directly on the accident site via video conferencing using smart glasses. The platform permits the transmission of vital parameters of a patient without delays so the specialist can follow the patient remotely and advise paramedics simultaneously. The preliminary results show that although the platform adds workload for the paramedics, it can add value for patient care because the emergency physician was more secure in giving advice when he/she could see the video and the vital parameters sent directly from the accident site. Furthermore, the emergency physician saw an added value in the capacity to prepare the arrival of the patient at the hospital, improving the continuity of care.

I. INTRODUCTION

Working in teams of two, paramedics are trained to face various medical situations from a broken leg to a cardiac arrest. On accident sites, they have minimal communication with the hospital to know more about a patient history, current medications, allergies or to get medical advice from more experienced medical specialists. In difficult cases, paramedics communicate by phone with the hospital and have to describe with words the situation they face. This communication is stressful for the paramedic trying to get his/her message across. For a physician at the hospital on the other side it is sometimes difficult to understand what precisely is happening at the accident site. This leads to confusion and sometimes the physician has to go to the accident site after the paramedics have arrived. This situation puts a toll on medical emergency situations in terms of time and money.

A platform offering video conferencing capability and transfer without much delay of vital parameters of patients to a medical center can help paramedics directly on accident sites. With the video conference, paramedics can access expert knowledge from a more experienced physician located at a medical center specialized in a specific health issue. With the transfer without much delay of vital parameters (Electrocardiogram–ECG pulse, peripheral pulse, non invasive blood pressure–NIBP, SpO_2 and 12 lead ECG), the more experienced physician can see directly on his/her computer screen if the patient is getting better or worse after giving directions to paramedics on the accident site. At this stage, the platform works with smart glasses worn by paramedics. Smart glasses have the advantage of being easily placed on paramedics safety glasses so the hands of paramedics are free to continue working while gathering information from the hospital. Moreover, as illustrated in Fig. 1 smart glasses carry a front facing camera so a physician at the hospital can see what is happening in front of a paramedics on the accident site and react accordingly. Last, smart glasses feature a small screen in front of one eye able to display information from the patient. The platform is based on previous work [1]. The platform has 5 main objectives:

- Enabling a better communication between paramedics and receiving hospitals;
- Faster access to expert advice on patient care;
- Ability to communicate data and integrate into health record;
- Possibility to apply the platform in a large scale across various hospitals and paramedics;
- Providing continuing education for paramedics and education to medical interns in the emergency department.

Smart glasses have emerged for a while with varying degrees of success. The most famous project, Google Glass, initiated by Google in 2014, appeared to be very promising. A project using Google Glass for paramedics was launched in 2014, but Google Glass rapidly showed a lack of connectivity stability and very short battery life when video conferencing was used [1]. Beside Google Glass, other manufacturers presented their versions of smart glasses [2]. Among them, Vuzix proposes the M100 smart glasses that are very similar to Google Glass, with a screen in front of one eye, WiFi and Bluetooth connectivity, as well as a camera filming in front of the user as illustrated in Fig. 1. The Vuzix M100 has several advantages compared to its counterpart made by Google. For example, the camera can be attached on both sides of security glasses or medical glasses, fitting right– and left–handed people. The connectivity is also more stable and the battery life is long enough to be used in professional settings. As illustrated in Fig. 1, The Vuzix M100 smart glasses feature a camera recording video Full HD and taking pictures at a resolution of 5 Megapixels of what is in front

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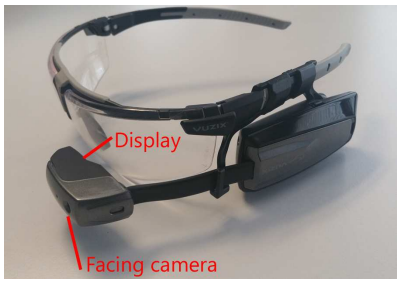

Fig. 1: Vuzix M100 smart glassses used by paramedics.

of the user. The smart glasses also feature a 16:9 full color screen where information can be displayed. In this study, we display the second derivative of the ECG along with NIBP and SpO_2 on the smartglass screen when the video conference with the hospital is not active.

Allowing users to keep working with their hands while performing a video conference, smart glasses enable the development of new health applications that can facilitate the workflow of medical employees. Many researchers have used smart glasses in various applications [3], [4], [5]. An exploratory study investigated for instance medical usability of Google Glass during 4 weeks in a hospital [4]. Voice recognition as well as latency, lag time and visual quality of local and transatlantic videoconferencing were tested. The findings demonstrated that such smart glasses can be useful in various medical tasks. Other researchers have investigated the use of smart glasses to access Electronic Health Records (EHR). They found that using smart glasses reduced the average daily time spent working on the EHR from 53% to 15% and increased the time physicians can spend directly with patients from 35% to 70% [2]. Following the same idea, a research group tested a novel way for interfacing a medical image retrieval system using smart glasses [3]. Using this system, medical doctors can take a photo of a medical case directly using the smart glasses, adding keywords using the voice command. The system would perform an image–based search and return results directly onto the screen of the smart glasses. The idea of the project was to mainstream access to information during physician visits.

A few studies using smart glasses in emergency situations have already been published. For example, researchers presented a system to help first responders communicate after a disaster [6]. This system is built on an array of routers directly placed around the disaster site. Each first responder could communicate with an expert user responsible to foresee the stage of emergency of the situation. In addition, they used Bluetooth beacons to track each patient to the hospital. To the best of our knowledge, there is no report on the use of a platform combining smart glasses and telemedicine for paramedics usable in everyday situations.

Using Vuzix M100, we were able to have a working prototype allowing paramedics to contact a hospital physician and to stream vital parameters from the accident site directly over a mobile network to the hospital based on a previous work [1]. In addition, this prototype allowed to

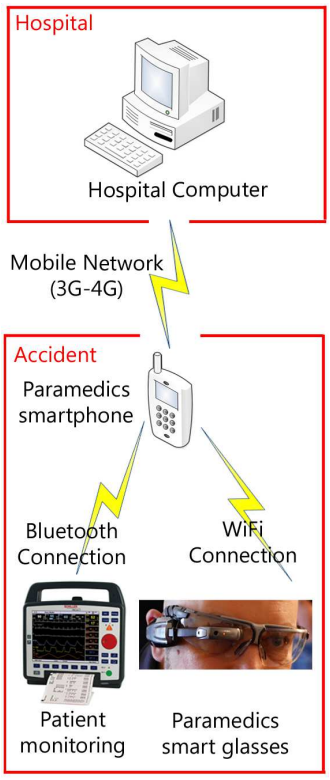

Fig. 2: Platform used to send information from the accident site to the specialist at the hospital.

send pictures from the accident site directly to the hospital, helping physicians to assess the kinematics of an accident in order to give the best care to a patient. In order to investigate whether this approach can be of interest in real medical settings, we conducted a pilot study involving 2 teams of professional paramedics, 1 emergency physician and 1 emergency nurse.

II. METHODS

A. Participants

Outside the hospital, 2 teams of 2 professional Swiss paramedics participated in the study. There were 1 woman and 3 men, aged between 25 and 43 years with at least 4 years of experience as professional paramedic. In the emergency department, 1 male emergency physician aged 39 years with extensive experience in emergency care was assisted by a male emergency nurse. All participants were employees of Hopital du Valais, Sion, Switzerland. They all volunteered to participate in the study and were paid by the hospital as it was a regular continuous training. No participant had prior experience with the platform nor with smart glasses in general.

B. Communication Platform

The study was designed to investigate the changes introduced by a new communication platform using smart glasses for emergency situations. This platform has 3 main features; (1) it allows the lead paramedic to perform an audio and video communication with a physician at the hospital to get

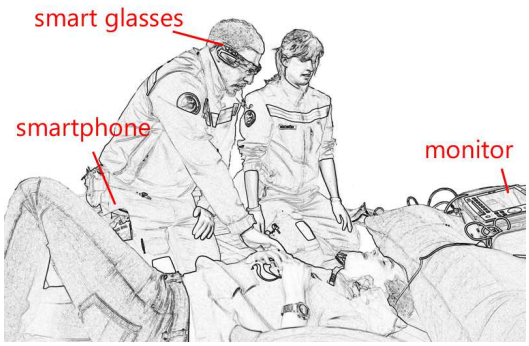

Fig. 3: Paramedics communicating with the hospital.

precise information about a patient, to get medical advice or to perform medical acts delegated under remote supervision; (2) it allows the physician to get a grasp of what is happening on the accident site through photos and videos directly sent from the accident site and; (3) it allows visualizing vital parameters (ECG pulse, peripheral pulse, Non Invasive Blood Pressure–NIBP, SpO_2 and 12 lead ECG) of a patient on the accident site without much delay. As illustrated in Fig. 2, the platform is composed of several devices. On the accident site an ARGUS Pro LifeCare 2 (Schiller AG, Baar, Switzerland) (APLC2) monitors the vital parameters of a patient and sends them via Bluetooth to an Android smartphone (Samsung Galaxy S5, Samsung, South Korea) as depicted in Fig. 3. A pair of Vuzix M100 smart glasses connect through the WiFi network created by the smartphone and send/receives audio and video communication. The smart glasses are also connected to the monitoring system and can display vital parameters of a patient. This can be useful if the screen of the APLC2 is out of the paramedics' sight. The main interest of the smartphone is to translate data received on the Bluetooth and WiFi channels to the 3G and 4G mobile network and vice versa. During the test, the Swisscom mobile network was used. On the hospital side, a server running a Node.js application receives the vital parameters of the patient and transmits them to a laptop (Satellite Z30–A, Toshiba, Tokyo, Japan) using the WebSocket protocol where the emergency physician is located as shown in Fig. 4.

C. Fictive Medical Emergency Situations

In this pilot study, we designed 4 fictive emergency situations that are common for medical first responders.

1) Heart problem 1 – Male patient, 79 years old, semi–conscious. He is suffering of chest pain and nausea. The monitoring shows signs of bradycardia. Atropine is administrated without effect. Pacing permitted under emergency physician supervision. Emergency physician is not available to come on site.
2) Hypoglycemia – Diabetic male patient, 38 years old. His wife calls the ambulance due to trouble of consciousness of her husband. Emergency physician is not available to come on site.
3) Heart problem 2 – Female patient, 64 years old. She is conscious but drowsy. She looks livid and has perspiration and chest pain. The monitoring shows supraventricular tachycardia.
4) Trauma – Male patient, 25 years old. He was removing Christmas lights from a window and fell on the street 10 meters below. He is facing the ground not moving.

Fig. 4: Emergency physician helping paramedics from the hospital.

D. Procedure

To investigate the changes introduced by the new platform, we performed the 4 fictive emergency situations twice during one full day of test. Once using the current state–of–the–art communication protocol using a cellphone to communicate between the paramedics and the hospital and once using the platform with video conference and web–based platform displaying the vital parameters. One team of paramedics was handling the 2 first situations with the help of smart glasses and the 2 last situations without smart glasses. The other team took care of the 2 first situations without smart glasses and the 2 other with the help of smart glasses. Both teams worked simultaneously on 2 different situations at one time. Each situation lasted roughly 1.5 hours. The emergency physician was in contact with both teams and received the patients of both teams one after the other at the hospital. Before using the platform with smart glasses, paramedics and emergency department staff were given a brief introduction (less than 10 minutes) about how to use the platform and the smart glasses and what to expect from the platform. After each situation, paramedics and emergency department staff were given a questionnaire asking whether they were satisfied with the communication means they were using and what changed during the intervention when they were using the platform. At the end of the day, a group debriefing was run to get the general feeling about the advantages and disadvantages of the platform over the state–of–the–art mobile communication.

E. Data Analysis

On the questionnaire for paramedics, the questions we processed for this pilot sudy were (1) Are you satisfied with the means of communication mean used in this emergency situation? (2) Are you satisfied with the ease of use of the mean of communication. On the questionnaire for emergency department staff, we processed the following questions (3) Did you delegate medical acts to paramedics when asked? (4) if yes, were you comfortable doing so? (5) Did you feel that you controlled the situation during the communication?

We combined answers from all situations in one aggregated ratio for each question.

III. RESULTS

The preliminary results show that for question (1), 100% of paramedics were satisfied with the state–of–the–art communication protocol using a cellphone to call the hospital whereas 85% were satisfied with the new platform. For question (2), 93% of paramedics found the state–of–the–art communication protocol easy to use whereas 81% found the plateform easy or partially easy to use. For the emergency department staff, the emergency physician delegated 100% of the medical acts using both communication protocols in question (3). However when answering question (4), he felt partially sure 100% of time when using the state–of–the–art communication protocol whereas when using the platform he felt sure 66% of the time and 33% partially sure. Answering question (5), he felt very limited control 66% of the time and a partial control 33% of the time using the state–of–the–art communication protocol whereas using the platform, he felt in control 100% of the time.

IV. DISCUSSIONS

Technically, the platform was able to process the data for all 4 situations without any software problem. During the second situation, after two hours displaying ECG data and multiple calls to the hospital, the smart glass battery was discharged but the this problem was solved by plugging an external battery into the smart glasses. The emergency situation could continue as expected. Only the video conference was unavailable for a brief moment. The rest of the system (transmission of vital parameters) was not affected by this problem. This never happened again as smart glasses were partially recharged when not in use.

On the usability front, it appears that paramedics are used to gather information purely with a phone call and they feel that this way of communication is enough. But this is normal for technologies that change the way they are trained to perform their work. Studies have shown that workers need time to adapt to a new sytem and a learning curve is always present at the beginning [7], [8]. With minimum time to introduce the platform, the idea was to see if the platform was user friendly enough to be used out of the box. The results show that it was easy for the paramedics to connect to the platform and the emergency physician could rapidely have access to the vital parameters of a patient. However, some functionalities such as the transmission of still image were not used often. This was due to the fact that they forgot about this functionality because it needed more user interaction to activate it.

On the relationship between paramedics and patient aspect, paramedics are often confronted to people in social and emotional distress. During such situations, they found that smart glasses added a social proxy between them and the person playing the patient. Nevertheless, paramedics felt more secure during the emergency situation knowing that they could easily ask for help from the hospital if needed.

The emergency physician at the hospital had another vision on the platform. Although he delegated all medical acts needed on the accident site when he was asked by telephone or through the platform, he felt much more comfortable doing so using the platform, as he was able to see the patient and what the paramedic was doing. He also had access to the current vital parameters of the patient on his screen at the hospital, so he could follow precisely the evolution of the patient. For example, during the fictive emergency situations related to cardiac problems (Heart problem 1 and Heart problem 2), patients were still conscious when paramedics arrived. To help the patients, paramedics had to do a cardioversion. In Switzerland, cardioversion can be performed by paramedics only under medical physician delegation. In both situations, the emergency physian delegated the cardioversion. However, he felt more in control when delegating the cardioversion over the platform compared to over the phone. The main reason for this feeling was the visual confirmation brought by the video conference and the confirmation of the necessity of cardioversion shown by the transfer of vital parameters on his screen.

The goal for the hypoglycemia situation was to investigate if the emergency physician would allow the patient to stay at home as the patient had a good knowledge about his disease and already partially recovered from his hypoglycemic episode. In both conditions, the emergency physician asked the paramedics to bring the patient at the hospital. During the debrifing interview, the reason was that the platform helped him to assess the patient, but he was not accustomed to leave people home when paramedics are on site. For the trauma situation, scoop and go without much advice from the emergency physician was the best option. However, images of the accident and live vital parameters of the patient can first help the receiving hospital to get prepared by calling medical specialists before the arrival of the ambulance and second help medical staff to understand the fall-induced injuries of the patient.

The transmission of data between the paramedics crew and the emergency department staff is often a problem. A study demonstrated that 43.4% of the information transmitted by the paramedics to the hospital staff was lost due to the state of emergency of the situation [9]. Often the emergency department staff redoes most tests and monitoring already done by the paramedics on the way to the hospital. The platform under test can make a permanent record of vital parameters for future diagnosis that allows to get access to the data by all medical staff involved in the patient care. This has the potential to save time and resources during the acute care and, more importantly, it has the potential to improve the patient's medical outcome. More studies on this aspect are needed to confirm the potential.

The preliminary results show that the communication platform does not provide added values in all situations faced by paramedics, for example during social interaction, but can improve the patient management from the time the paramedics arrive on the accident site and until patient discharge at the hospital.

V. CONCLUSION

This paper describes a pilot study aiming at assessing the added–value introduced by a novel platform combining video conference ability and telemedicine approach. As expected, such a platform introduces added–value especially for patient management starting at the accident site. However, it does not need to be used in all situations because it adds workload for the paramedics on site and can add a communication barrier between paramedics and the patient. Nevertheless, a larger study needs to be performed to confirm the observations made in this pilot study.

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