The Feasibility and Acceptability of Google Glass for Teletoxicology Consults

Peter R. Chai¹ · Kavita M. Babu¹ · Edward W. Boyer¹

Published online: 6 August 2015

© American College of Medical Toxicology 2015

Abstract Teletoxicology offers the potential for toxicologists to assist in providing medical care at remote locations, via remote, interactive augmented audiovisual technology. This study examined the feasibility of using Google Glass, a head-mounted device that incorporates a webcam, viewing prism, and wireless connectivity, to assess the poisoned patient by a medical toxicology consult staff. Emergency medicine residents (resident toxicology consultants) rotating on the toxicology service wore Glass during bedside evaluation of poisoned patients; Glass transmitted real-time video of patients' physical examination findings to toxicology fellows and attendings (supervisory consultants), who reviewed these findings. We evaluated the usability (e.g., quality of connectivity and video feeds) of Glass by supervisory consultants, as well as attitudes towards use of Glass. Resident toxicology consultants and supervisory consultants completed 18 consults through Glass. Toxicologists viewing the video stream found the quality of audio and visual transmission usable in 89 % of cases. Toxicologists reported their management of the patient changed after viewing the patient through Glass in 56 % of cases. Based on findings obtained through Glass, toxicologists recommended specific antidotes in six cases.

Head-mounted devices like Google Glass may be effective tools for real-time teletoxicology consultation.

Keywords Mobile health · Telemedicine · Wearable devices · Google Glass · Toxicology

Introduction

Teletoxicology has been theorized to extend the reach of medical toxicologists from academic medical centers to distant health-care facilities where most poisoned patients receive care [1]. Modern wireless infrastructure, miniaturization of hardware, and improved penetration of cellular phones, computers, and tablets have advanced the use of mobile technology into health-care settings. However, no advanced technologies have yet been deployed to assist in the remote diagnosis and management of the poisoned patient [2, 3].

Head-mounted devices (HMDs) such as Google Glass have recently emerged as an unobtrusive method for a wearer to receive information while transmitting first-person images and video to a remote viewer [4]. Because of their intuitive control and unobtrusive nature, HMDs pose a solution that allows a toxicologist to examine poisoned patients virtually at the bedside, in conjunction with the consulting physician [1, 3, 5]. Glass and other HMDs, worn like a pair of eyeglasses, project information at eye level through a prism display, provide access to internet-enabled applications, and can function as a head-mounted telephone through a Bluetooth connection to a cellular phone. Because Glass represents a fundamentally new level of connectivity and data acquisition and transmission, we sought to determine the feasibility of integrating Google Glass into a medical toxicology consult service.

Portions of data from this manuscript were presented at the 2015 American College of Medical Toxicology Scientific Forum

✉ Peter R. Chai
peter.chai@umassmemorial.org

¹ Division of Medical Toxicology, Department of Emergency Medicine, University of Massachusetts Medical School, 55 Lake Ave North, Worcester, MA 01655, USA

Methods

We performed our study at a large, urban academic emergency department, which is home to a toxicology consult service. Our study protocol, reflecting similar methodology used in nascent telestroke and teletrauma research, was approved by our hospital institutional review board. We modified Google Glass (Mountain View, CA) by first disabling all native software (e.g., Google Chrome, Picasa, and Maps). We then embedded the Pristine Eyesight (Austin, TX) operating system, a third-party, health information portability and accountability act (HIPAA)-compliant video platform. When running the Eyesight software, Glass wirelessly streams live, first-person video feeds to a remote viewer. In addition, the remote viewer is able to communicate with the Glass wearer through either the computer microphone or HIPAA compliant text messages. The Glass wearer is also able to take static snapshots that are transmitted to the remote viewer. In our study, second-year emergency medicine residents (“resident toxicology consultants”) on the toxicology rotation wore Glass while performing bedside consultations; images from Glass were wirelessly transmitted to a medical toxicology fellow or attending (“supervisory consultants”) for remote viewing (Fig. 1).

Resident toxicology consultants and supervisory consultants underwent a brief training session to use Glass by the study’s lead investigator (PRC) who had prior experience in the use of the device [6]. Training included basic use of Glass, learning to connect it to the hospital wireless network, using voice commands and head gestures to initiate a video consult, and using the camera function on Glass. After training to use Glass, resident toxicology consultants received standard

consultations consisting of verbal presentations of poisoned patients in the emergency department from emergency department staff. Resident toxicology consultants used our consult service’s standard patient data template form to extract information regarding the nature of the consult, likely etiologic agent, and pertinent physical exam findings. Resident toxicology consultants then completed a survey regarding the suspected toxidrome with information gleaned from the case presentation. Because our study focused on the feasibility of this technology, specific demographics on poisoned patients were not obtained. On days when a Glass-trained resident and fellow or attending were available, adult poisoned patients who presented to the emergency department during the hours of 9 a.m. to 5 p.m. were eligible for additional evaluation through Glass. Resident toxicology consultants wearing Glass evaluated patients at bedside, with a secure video feed projected to supervisory consultants. Supervisory consultants then guided the resident toxicology consultants using text messages that projected onto the display on Glass. Resident toxicology consultants obtained static photos of medication bottles and electrocardiograms (EKGs) at the discretion of their supervisors.

Immediately after the consult, supervisory consultants completed a survey regarding their experience viewing a teleconsult through Glass, and the technical feasibility of the Glass teleconsult. The survey instrument was developed to assess the feasibility of deploying a novel head-mounted device in our toxicology service. Surveys were anonymous and completed online immediately after the patient encounter through the REDCap database in a closed format [7]. In the event that the supervisory consultant recommended an antidote, a free text box was available to document the antidote used.

Fig. 1 Study design and workflow

Results

During our study period, we attempted 19 consults through Glass. We were able to successfully complete 18 consults. In one case, we were unable to establish a wireless connection to our hospital network with Glass, and aborted the video consult (Table 1).

In 89% of cases, consults through Glass were considered successful by the supervisory consultant ($N=16$) (Table 2). Interruptions in the video feed (video lag) occurred during four consults; audio lag was present in only one consult that did not compromise the quality or usability of the Glass consult. In one instance, we experienced both audio and video lag during a consult that rendered the Glass consult unusable.

Prior to viewing the poisoned patient through Glass, supervisory consultants reported confidence in diagnosing a specific toxidrome in 59 % ($N=10$) of cases (Table 3). After a virtual exam through Glass, the confidence of supervisory

Table 1 Characteristics of toxicology consult patients seen through Google Glass

Patient	Age	Gender	Suspected poisoning after phone consult	Suspected poisoning after Glass consult	Did Glass consult change management?
1	50–69	Female	Opioid	Opioid	Yes
2	50–69	Male	Beta-blocker	Beta-blocker	No
3	50–69	Male	Sedative/hypnotic	Sedative/hypnotic	Yes
4	50–69	Female	Serotonin syndrome	Sedative/hypnotic	Yes
5	30–49	Female	Sedative/hypnotic	Lithium	Yes
6	50–69	Female	Sedative/hypnotic	Sedative/hypnotic	Yes
7	18–29	Male	Sedative/hypnotic	Cannabis	No
8	30–49	Female	Sedative/hypnotic	Sedative/hypnotic	Yes
9	30–49	Male	Carbon monoxide	Carbon monoxide	No
10	50–69	Female	Carbon monoxide	Carbon monoxide	No
11	50–69	Male	Carbon monoxide	Carbon monoxide	Yes
12	50–69	Male	Carbon monoxide	Carbon monoxide	No
13	30–49	Male	Carbon monoxide	Carbon monoxide	No
14	18–29	Male	Isopropyl alcohol	Isopropyl alcohol	Yes
15	50–69	Male	Sedative/hypnotic	Sedative/hypnotic	No
16	30–49	Female	Sympathomimetic	Sympathomimetic	No
17	30–49	Male	Anticholinergic	Opioid	Yes
18	50–69	Female	Sedative/hypnotic	Sedative/hypnotic	Yes

consultants in diagnosing a specific toxidrome increased to 94 % ($N=17$). While specific management of patients was outside the focus of this study, we were able to obtain preliminary data on user experience. Supervisory consultants reported that the virtual exam through Glass changed management of the patient in 56 % ($N=10$) of cases. Supervisory consultants also reported that the Glass virtual exam contributed to use an antidote (e.g., naloxone for an opioid toxidrome and hyperbaric oxygen for a carbon monoxide poisoning) in six patients who otherwise would not have received any antidote. In addition, the history prompted from the supervisor during one consult revealed an acetaminophen ingestion that deserved treatment with N-acetylcysteine. Examples of where Glass changed management included (1) recommending admission to a critical care unit in a patient found to have significant respiratory depression requiring naloxone infusion, (2) transferring a patient with carbon monoxide exposure to an outside facility with a hyperbaric chamber, and (3) hospital admission for acetaminophen ingestion.

Discussion

Our data suggest that Google Glass is a feasible head-mounted device for remote toxicology consults. We believe that data transmitted by Glass allows a remote toxicologist to validate historical details and physical examination findings reported by bedside clinicians. Moreover, the data transmission from Glass is of sufficient quality to allow diagnosis of specific toxidromes in clinical environments that lack a bedside toxicology consult service. The importance of this research, therefore, is that HMDs such as Glass can place a remote toxicologist virtually at the bedside with a physician providing direct patient care in any location [1, 3].

We also found preliminary evidence that Glass may affect patient management. Although not the focus of this study, supervisory consultants reported their management decision changes largely centered on the disposition of poisoned patients to the inpatient setting versus medical clearance to a mental health facility. On at least one occasion, the

Table 2 Connectivity and feasibility of Glass for toxicology consults

Characteristic	Yes ($N=18$)	No ($N=18$)
Successful video connection during Glass consult	78 % ($N=14$)	22 % ($N=4$)
Successful audio connection during Glass consult	94 % ($N=17$)	6 % ($N=1$)
Successful Glass consult	89 % ($N=16$)	11 % ($N=2$)
Preferred Glass over standard webcam conference	94 % ($N=17$)	6 % ($N=1$)

Table 3 Toxicology consultant confidence in identification and management of poisoned patients with Glass

Characteristic	Agree (N=18)	Disagree (N=18)
I am confident in the toxidrome after phone consultation	56 % (N=10)	44 % (N=8)
I am confident in the toxidrome after Glass consultation	94 % (N=17)	6 % (N=1)
My management plan changed after Glass consultation	56 % (N=10)	44 % (N=8)
I recommended an antidote after Glass consultation that I otherwise would not have	33 % (N=6)	67 % (N=12)

supervisory consultant identified a patient who required naloxone continuous infusion for recurrent respiratory depression and hypoxia. In a second case, the real-time, heads up text messages from the supervisory consultant improved the precision of the medication history obtained by the physician at the bedside, an event that prompted administration of N-acetylcysteine. These findings indicate that Glass-augmented examinations may have a role in improving the quality of protocol-driven management recommendations provided by poison control centers. However, further studies to determine the role of Glass in the remote care of poisoned patients are required now that feasibility has been established.

In the present era of value-based care, a toxicology service using Google Glass could expand their coverage of health-care systems and decrease overall treatment costs [8–11]. Importantly, a simple, unobtrusive HMD such as Glass has the potential to generate revenue (using comparable billing codes used by telestroke services to generate income) that may be applied to toxicology faculty support. Teletoxicology consults can increase the number of bedside consultations for fellows in training, decrease the reliance of fellowship programs on poison control centers, and improve the care of poisoned patients [12, 3, 13]. By placing an expert at the virtual bedside, Glass can provide additional exposure to a toxicology service with concomitant increases in educational opportunities.

HMDs like Google Glass pose a distinct advantage when compared with traditional telemedicine platforms. Their relative unobtrusiveness and acceptance by patients combined with the hands-free nature and extreme portability of the devices make them ideal for a busy, crowded emergency department [6, 1]. Like other telemedical devices, privacy and security of patient information will remain paramount as breaches in data transmission can be damaging to the patient and the telemedical program [1]. Prior to deployment of Glass, we developed close partnerships with industry partners and our hospital information technology and security departments to ensure adequate steps were taken to secure data transmission. Future investigations can explore the potential of reimbursement in patients evaluated through HMDs, and long-term sustainability of a HMD for virtual toxicology consults.

Rapid technology advancement and device cycles remain an important consideration to choosing a platform for establishing a teletoxicology service [14]. During our study period,

the commercial Google Glass Explorer program which had provided Glass to many providers abruptly ended [15]. We were able to maintain technical support through existing industry partners. Toxicologists who consider a HMD as a telemedical platform should ensure enduring support in the event of device upgrades. In piloting the use of this HMD, we utilized a multidisciplinary team of toxicologists, hospital security and information technology officers, and industry partners to ensure adequate connectivity while minimizing audio and video lag [1, 16]. Newer iterations of HMDs will likely lead to improved device stability and connectivity with additional functionality. A toxicology consult service will likely benefit from assessment of these novel advanced devices.

Limitations

This study has several limitations. This investigation was based at a single institution, and was dependent on the availability of Glass-trained supervisory consultants and resident toxicology consultants. We leveraged our existing toxicology consult service that is tied to an academic fellowship. This relationship allowed us to have residents participating in the toxicology rotation assess poisoned patients at the bedside—a luxury that a solo toxicology practitioner may lack. Having Glass available within our toxicology service may have led to bias from resident toxicology consultants knowing that patients would have a subsequent video consultation as they evaluated patients at the bedside. However, our study was one of feasibility, where audio and video connectivity were our main outcomes.

Our study was conducted on a convenience basis when Glass-trained personnel were available. Future studies will evaluate the use of Glass during both daytime and nighttime hours, using a randomization scheme. During our feasibility study, the time it took to complete a consult, and the speed at which recommendations were conveyed to the primary team were not measured. However, feedback from bedside providers suggested that recommendations on poisoned patients were received faster than in the standard toxicology consult. Future studies will address the timeliness of teletoxicology consults. In evaluating the technical feasibility and

connectivity of a heads up device for toxicologic evaluations, we did not compare triage decisions, or outcomes of patients made over the phone to those made through Google Glass.

Conclusions

In this initial study on the feasibility of a HMD for remote toxicology consults, Google Glass was demonstrated to be a feasible option for creating a teletoxicology service.

Funding Sources This research was supported in part by National Institutes of Health grant 1K24DA037109 Title: Mentoring in advanced mHealth interventions for drug abuse and HAART adherence (PI: Boyer).

Conflict of Interest This paper is not currently under consideration for publication in other journals. The authors declare that they have no competing interest.

References

- Chai PR, Wu RY, Ranney ML, Porter PS, Babu KM, Boyer EW. The virtual toxicology service: wearable head-mounted devices for medical toxicology. *J Med Toxicol : Off J Am Coll Med Toxicol*. 2014. doi:10.1007/s13181-014-0420-5.
- Maddry JK, Sessions D, Heard K, Lappan C, McManus J, Beberta VS. Wartime toxicology: evaluation of a military medical toxicology telemedicine consults service to assist physicians serving overseas and in combat (2005-2012). *J Med Toxicol : Off J Am Coll Med Toxicol*. 2014. doi:10.1007/s13181-014-0398-z.
- Skolnik A. Telemedicine and toxicology: back to the future? *J Med Toxicol : Off J Am Coll Med Toxicol*. 2013;9(3):217–9. doi:10.1007/s13181-013-0313-z.
- Google. Google I/O 2012. 2012. <https://developers.google.com/events/io/2012/>.
- Fischbein CB, Mueller GM, Leacock PR, Wahl MS, Aks SE. Digital imaging: a promising tool for mushroom identification. *Acad Emerg Med : Off J Soc Acad Emerg Med*. 2003;10(7):808–11.
- Chai PR, Wu RY, Ranney ML, Bird J, Chai S, Zink B, et al. Feasibility and acceptability of Google Glass for emergency department dermatology consultations. *JAMA Dermatol*. 2015. doi:10.1001/jamadermatol.2015.0248.
- Harris PA, Taylor R, Thielke R, Payne J, Gonzalez N, Conde JG. Research electronic data capture (REDCap)—a metadata-driven methodology and workflow process for providing translational research informatics support. *J Biomed Inform*. 2009;42(2):377–81. doi:10.1016/j.jbi.2008.08.010.
- Clark RF, Williams SR, Nordt SP, Pearigen PD, Deutsch R. Resource-use analysis of a medical toxicology consultation service. *Ann Emerg Med*. 1998;31(6):705–9.
- Lee V, Kerr JF, Braitberg G, Louis WJ, O'Callaghan CJ, Frauman AG, et al. Impact of a toxicology service on a metropolitan teaching hospital. *Emerg Med (Fremantle, WA)*. 2001;13(1):37–42.
- Vassilev ZP, Marcus SM. The impact of a poison control center on the length of hospital stay for patients with poisoning. *J Toxic Environ Health A*. 2007;70(2):107–10. doi:10.1080/15287390600755042.
- Zaloshnja E, Miller T, Jones P, Litovitz T, Coben J, Steiner C, et al. The potential impact of poison control centers on rural hospitalization rates for poisoning. *Pediatrics*. 2006;118(5):2094–100. doi:10.1542/peds.2006-1585.
- Wiegand TJ, Crane PW, Kamali M, Reif M, Wratni R, Montante R, et al. Billing and reimbursement for a bedside toxicology service at a tertiary care academic center during its first fiscal year. *J Med Toxicol : Off J Am Coll Med Toxicol*. 2014. doi:10.1007/s13181-014-0423-2.
- Thompson TM, Leikin JB. Lessons learned from the reimbursement profile of a mature private medical toxicology practice: office-based practice pays. *J Med Toxicol : Off J Am Coll Med Toxicol*. 2015;11(1):59–64. doi:10.1007/s13181-014-0450-z.
- Myers MR. Telemedicine: an emerging health care technology. *Health Care Manag*. 2003;22(3):219–23.
- Glass G. We're graduating from Google[x] labs. Google Plus; 2015.
- Guerra W, Block S, Gordon M, Seville P, Lopez N, Wright K et al. Mobile Health Roadmap: mHealth Strategic Framework for Hospitals and Health Systems. In: Society HIMSS, editor. <http://www.himss.org/mobilehealthit/roadmap2012>.