Google Glass for Residents Dealing With Pediatric Cardiopulmonary Arrest

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Google Glass for residents dealing with pediatric cardiopulmonary arrest
A randomized, controlled, simulation-based study

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Abstract

Objective: To determine whether real-time video communication between the first responder and a remote intensivist via Google Glass (GG) improves the management of a simulated in-hospital pediatric cardiopulmonary arrest (pCPA) before the arrival of the intensive care unit team.

Design: Randomized controlled study.

Setting: Children's hospital at a tertiary care academic medical center.

Subjects: 42 first-year pediatrics residents.

Interventions: Pediatrics residents were evaluated during two consecutive simulated pCPAs with a high-fidelity manikin. During the second evaluation, the residents in the GG group were allowed to seek help from a remote intensivist at any time, by activating real-time video communication. The residents in the control group were asked to provide usual care.

Measurements and Main Results: The main outcome measures were the proportion of time for which the manikin received no ventilation (no-blow fraction) or no compression (no-flow fraction). In the first evaluation, overall no-blow and no-flow fractions were 74% and 95%, respectively. During the second evaluation, no-blow and no-flow fractions were similar between the two groups. Insufflations were more effective ($p=0.04$) and the technique ($p=0.02$) and rate ($p<0.001$) of chest compression were more appropriate in the GG group than in the control group.

Conclusions: Real-time video communication between the first responder and a remote intensivist through GG did not decrease no-blow and no-flow fractions during the first five minutes of a simulated pCPA, but improved the quality of the insufflations and chest compressions provided.

Introduction

Pediatric cardiopulmonary arrest (pCPA) is rare(1–5). Most cases of in-hospital pCPA occur in intensive care units (ICU), a trend accentuated in recent years(6, 7). The gap in pCPA management experience between ICU teams and individuals called upon to provide "first-responder" care outside of the ICU is thus widening. Several studies have found the quality of care delivered by first responders outside the ICU to be well below the standards set by international guidelines(8–10), decreasing the patient's chances of survival(11).

With the advent of real-time video communication, it should be possible for first responders to "use the talents of other health professionals"(12), thereby closing the gap between novices and experienced providers in this emergency situation. An audio-video link between the first responder and a remote intensivist has already been shown to improve resuscitation quality in CPR(13, 14), but these studies were limited to out-of-hospital cardiac arrest and did not involve health professionals as first responders. In a different context, the use of video-assisted resuscitation during a simulated neonatal resuscitation scenario improved care-provider performance (15), but it remains unclear whether these findings can be generalized to pCPA. Furthermore, none of these studies used a head-mounted device, such as Google Glass (GG), to establish audio-video communication, but this technology may present several advantages in resuscitation contexts, such as the possibility of hands-free use by the first responders and the provision of a first-hand view of the situation to the remote intensivist.

In this study, first-year pediatrics residents were equipped with this device. Our main objective was to determine whether real-time video communication, via GG, between the resident dealing with the simulated case of pCPA and the remote intensivist, was associated with lower no-flow and no-blow fractions. Our secondary objectives were to determine

whether the quality of insufflation and chest compression was higher and whether the times to first ventilation, first compression, and adrenaline prescription were lower in the GG group.

2. Materials and Methods

2.1 Population and randomization

A randomized controlled trial was conducted at the Pierre & Marie Curie School of Medicine (UPMC Université Paris 6, Paris, France). The participants were first-year residents in pediatrics in Paris, at the start of their residency.

The participants were randomized by placing paper slips marked with one of the two options, GG or control, into opaque envelopes and asking the participants to select an envelope. Randomization was carried out in blocks of four, to ensure that groups of similar size were obtained.

The SRLF (*Société de reanimation de langue française*) Institutional Review Board approved the study and all participants gave written consent.

2.2 Study design

After randomization, the participants watched a five-minute video explaining how the high-fidelity manikin worked. They were then given 10 minutes to read the medical chart of the simulated patient. Each participant was evaluated on two simulations of pCPA in an eight-month-old infant (Laerdal SimBaby®) admitted for severe bronchiolitis, each lasting five minutes (Figure 1 and Table S1).

During the first evaluation, each participant had to manage the simulated pCPA alone. The objective was to assess their basic life support skills. The participants assigned to the GG group were then equipped with the device, whereas those assigned to the control group were not. No debriefing was provided between the first and the second evaluation. In the second evaluation, the participants from the two groups were assessed in a new pCPA scenario, with a nurse joining them in the 3rd minute. The arrival of the nurse enabled the participants to prescribe adrenaline, and time to this prescription was one of the outcomes measured.

At the end of these evaluations, all participants completed a questionnaire about their characteristics (Table S2). Several residents unable to participate in the study agreed to

complete the same questionnaire. The participants assigned to the GG group were also asked to complete another questionnaire concerning their impressions of the usefulness of GG in pCPA management (Table S3).

2.3 Intervention

During the second evaluation, the GG group residents were allowed to establish real-time video communication with an intensivist at a remote location (Figure 2 A-C). There is currently no commercial software for Wi-Fi audio-video transmission via GG. We therefore had to combine:

- An audio link via an iPhone 4S (Apple, California), with a hands-free kit.
- A video link via GG (Mountain View, California), using a 20-metre USB cable connecting the GG and a personal computer located in another room completely independent from the evaluation room (Figure S1). AMA (Advanced Medical Applications, Rennes, France) provided the GG equipment, and real-time video transmission was achieved with software they developed. The use of GG in resuscitation is still investigational.

When the participants felt that they required assistance from an intensivist, they activated the audio link. Once called, the intensivist activated the video link on his laptop. The intensivist was thus able to see, in real time, what the residents were seeing and to guide them via the audio link (Video available on https://www.youtube.com/watch?v=SCm6_Lw0pHE). The intensivist who provided feedback was the same person throughout the study (A.P.). He had been responsible for the pediatric advanced life support course provided to the 400 medical students of the Pierre & Marie Curie School of Medicine for 5 years(16). Immediately after establishing communication, the intensivist coached the resident in a directive manner. The intensivist did not ask the resident questions about what he or she intended to do next, but instead guided the resident step-by-step, following the algorithm of pediatric advanced life support from the 2010 European Resuscitation Council guidelines.

The intensivist began by asking the resident the reason for the call. He then assessed how far the resident had progressed in delivery of CPR. He asked the resident whether he or she had already checked that the airways were open and, if not, he told the resident to do so before continuing CPR. During this first stage of the intervention, there was an ongoing dialog between the intensivist and the resident. Once the resident had started to deliver insufflations and compressions in the correct ratio, the intensivist limited his interventions to correcting the technique used. Finally, when the nurse arrived, the intensivist asked the resident to prescribe adrenaline and gave him/her the dose and the route of administration.

The residents in the control group were asked to provide usual CPR. If they called the intensivist by phone, the specialist told them to continue CPR until the ICU team arrived. If the participant asked for instructions (e.g., the dose of adrenaline) the intensivist was allowed to answer, as during real resuscitation conditions in our hospital.

2.4 Data collection and outcomes

The main outcomes were the no-blow and no-flow fractions. We chose these outcomes because a previous study revealed that no-blow and no-flow fractions were as high as 35% and 88%, respectively, for first-year residents(9). The no-blow fraction was defined as the proportion of time for which the manikin went more than 10 seconds without insufflation. The no-flow fraction was defined as the proportion of time for which the manikin received no compression. These data were calculated from the start and stop times for ventilations and compressions extracted from the Laerdal SimBaby simulator log feature. We found no published information about the quality of the information collected by Laerdal SimBaby software, so we also collected these data manually from video records. Each CPA was videotaped and the video records were anonymized and randomly sorted. For each second recorded, two observers noted whether the manikin was receiving compression and/or ventilation.

The secondary outcomes included: (1) discrete, observable resuscitation-related actions, such as the suction of nasal secretions, the withdrawal of nasal prongs for ventilation, the use of bag valve mask, insufflation efficiency (assessed by monitoring the rising movement of the manikin's chest), compression rate (considered appropriate if between 100 and 120/min on assessment with a metronome) and technique (both the two-finger and two-thumb techniques were considered acceptable), and adrenaline dose; and (2) the times to first ventilation, first compression, and adrenaline prescription. We were unable to analyze the depth of compression, which cannot be recorded by the SimBaby automatic log feature.

Finally, we performed a post-hoc analysis on the reasons for CPR interruption. For each participant, once ventilation and compression had been initiated, periods of more than one second during which the manikin received neither insufflation (for more than 10 seconds) nor compression were identified. A cause was attributed to each of these periods.

2.5 Statistics

Sample size was calculated on the basis of a previous study evaluating medical students in simulations of pCPA(16). The mean time without compression was estimated at 240 seconds in the control group (standard deviation: 45 seconds). We expected a 20% improvement in the GG group after the initiation of compression. As compressions should begin before the 60th second in CPA, based on the remaining four minutes of the scenario, we expected to see an improvement of 48 seconds in the GG group. Assuming an alpha risk of 0.05 and a beta risk of 0.2, we needed 19 participants per group.

Data were analyzed with GraphPad Prism v5.03 (La Jolla, California). For continuous data, median values and interquartile ranges are reported, and cohorts were compared in Mann–Whitney U tests. Fisher's exact test was used for comparisons of categorical data. Pearson's correlation coefficient was calculated for the evaluation of inter-observer

reproducibility and to compare the manual and automatic records for no-blow and no-flow fractions.

Results

1) Population

Forty-two of the 79 (53%) individuals starting their residency in pediatrics in Paris participated in this study. After randomization, the characteristics of the residents assigned to the GG and control groups were similar (Table 1). The characteristics of participants were similar to those of 30 non-participants who accepted to complete the same questionnaire (Table 1).

2) Technical evaluation of GG

All GG group participants called the intensivist, whereas six residents in the control group did not call the intensivist at any point in the evaluation.

All the GG group participants (21) said that they found the audio-video link with the intensivist helpful. Seventeen (81%) were reassured by this link. Seven (33%) said that they completely forgot about the equipment, whereas six (29%) declared that the equipment impeded their management of the patient.

The quality of the video displayed and the fluidity of video transmission made it possible for the intensivist to provide the residents with guidance in real time. However, several limitations were identified. First, four participants (19%) needed to tie up their hair to prevent the GG camera from being hidden (Figure 2D). Second, two of the four participants with spectacles had to remove them to wear the GG. Finally, we identified a number of gaps between what the participant was observing (direction of gaze) and the range of the camera (Figure 2 E-F), resulting in a mismatch between what the participant and the intensivist were seeing. However, participants were able to see the images they were sending to the intensivist on their GG display, and this allowed them to correct their head position.

3) No-blow and no-flow fractions

Despite the randomization process, the no-blow fraction was higher in the GG group than in the control group during the first evaluation, whereas the no-flow fractions of the two groups were similar (Table 2 and Figure 3).

During the second evaluation, the no-blow and no-flow fractions were similar in the GG and control groups (Table 2 and Figure 3). The decrease in the no-blow fraction between the first and second evaluations was therefore larger for the GG group than for the control group (median decrease of 22 points (IQR: 13-38) versus 14 points (IQR: 1-18), respectively; p=0.007). We compared the simulator results with the manually collected data. Inter-observer reproducibility for the no-blow and no-flow fractions acquired manually was excellent, with correlation coefficients of 0.97 ($CI_{95\%}$: 0.96-0.98) and 0.99 ($CI_{95\%}$: 0.98-0.99), respectively (Table S4). The correlation between the manually and automatically collected data was strong for the no-blow fraction (0.69, $CI_{95\%}$: 0.48-0.83) but weak for the no-flow fraction (0.37, $CI_{95\%}$: 0.06-0.62). However, no-blow and no-flow fractions remained similar in the GG and control groups with both methods (Table S4).

CPR was more frequently interrupted by discussions with the intensivist in the GG group than in the control group (12 interruptions versus 4 in the control group, $p < 0.001$) (Figure 4). The number of residents who interrupted CPR to explain the medical situation to the intensivist was similar in the two groups (4 versus 3, p=1.00, Table S3). By contrast, more residents in the GG group interrupted CPR because of instructions from the intensivist on insufflation or chest compression technique, adrenaline prescription, or placement on a hard surface (10 versus 1, p=0.004, Table S5).

4) Resuscitation quality

During the second evaluation, the insufflations provided by participants in the GG group were more effective than those of control group. Compression technique and rate were also more appropriate in the GG group (Table 2). All participants in the control group

prescribed adrenaline, but nine (43%) were unable to prescribe the correct dose. Nineteen (90%) participants in the GG group prescribed adrenaline. Three prescribed an incorrect dose despite being told the correct dose by the intensivist. The times to first ventilation, first compression, and adrenaline prescription did not differ significantly between groups (Table 2).

Discussion

This is the first study to have evaluated the usefulness of GG communication between a resident and an intensivist at a remote location in the context of resuscitation.

The first evaluation confirmed that the quality of care delivered by new residents in pediatrics departments is well below the standards established by international guidelines. Our results are similar to those of another study of pediatrics residents carried out at Johns-Hopkins University: one quarter of our residents failed to initiate compression during the first five minutes, versus one third in the American study, and the no-flow fractions in these two studies exceeded 80%(9). The training of residents is essential to improve their performance, as such training increases their knowledge and compliance with international guidelines(17). However, in our opinion, training is necessary but not sufficient: knowledge and skills begin to deteriorate within as little as three months after training(18, 19), and the translation of skills from training environments to the setting of an actual cardiac arrest is another issue(8). There were therefore good reasons for evaluating the usefulness of real-time video communication between an intensivist at a remote location and the resident dealing with the pCPA.

We needed to choose the most appropriate device for a resuscitation context requiring technical skills, to maximize our chances of demonstrating the usefulness of real-time video communication in this context. We chose to use GG for four main reasons: (i) it was the most advanced smart glass available when this study was designed, (ii) it could be used in a hands-

free manner by the residents, (iii) the video camera was closer to the right eye in the GG system than in the GoPro system (San Mateo, California), and was therefore more likely to offer an accurate first-hand perspective, (iv) it allowed the resident to know, in real-time, what the intensivist was seeing, thanks to video feedback displayed on the GG screen.

All the residents in the GG group said that they found the audio-video link with the remote intensivist helpful for managing the pCPA. A previous study revealed that such video calls could improve the confidence of lay rescuers(20). However, no difference in no-blow and no-flow fractions was found between the GG and control groups, probably for two main reasons. First, the no-blow fraction was higher in the GG group than in the control group during the initial evaluation before the intervention. The lack of difference observed in the second evaluation may therefore indicate a better improvement in the initially poorer performance of the participants from the GG group. Second, we found that communication with the intensivist via the GG system was associated with interruptions in CPR. Participants often adopted a "listening attitude", forgetting the task at hand. These interruptions most occurred when the intensivist gave instructions to enhance CPR quality, such as explanations on how to improve insufflation or chest compression techniques. Just as exposure to a high workload has been shown to decrease the performance of pilots in aircraft simulator studies, so the high cognitive load associated with listening to the intensivist's instructions in our study was detrimental to CPR delivery to the manikin(21). This important finding demonstrates that audio-video communication cannot replace traditional training in basic and advanced life support. Trained residents able to perform effective insufflations and chest compressions will require fewer explanations from the intensivist, decreasing the risk of CPR interruptions. In such cases, the intensivist may take the role of a helper, answering the residents' questions, rather than that of a leader, directing the residents' actions. Moreover, the characteristics of communication may also be improved by effective training of the

resident. Short sentences, even reduced to a few words, such as “suction”, “5 insufflations”, “30 chest compressions”, “2 insufflations”, as used by surgeons during operations(22), may help to decrease the cognitive load. Finally, a large number of residents in both groups interrupted CPR whilst thinking about the dilution and dose of adrenaline to be used. We therefore recommend that first responders focus exclusively on the airway-breathing-circulation sequence, alternating insufflations and compressions.

Real-time audio-video communication with an intensivist had no effect on resuscitation “quantity” (no-blow and no-flow fractions), but it did improve its “quality”. Insufflations were more effective, and compression technique and rate were more appropriate in the GG group than in the control group. These findings are consistent with those of a previous study demonstrating that the quality of rescue breathing was improved by video communication(13). As CPA in children mostly results from hypoxia, ventilation is essential to improve survival and survival with a favorable neurological outcome(23). Therefore, the better quality of the insufflations provided in the GG group is an important finding (24).

Overall, our study demonstrates that the time taken by the intensivist to correct insufflation and compression techniques in the GG group led to improvements in CPR quality, without increasing the no-blow and no-flow fractions, which remained similar between groups. In studies involving lay rescuers, adding video to audio communication was also associated with better quality rescue breathing and chest compressions, but at the expense of longer no-blow and no-flow fractions(13, 14, 25). Thus, it appears that audio-video communication is more beneficial, in terms of both CPR quality and quantity, if the first responders have a higher level of training.

Given the technical limitations of GG noted in this study, we feel it would be too early to recommend the implementation of this device in resuscitation contexts. The gap between

the direction of the first responder's gaze and the GG video camera could be overcome by a short training session, but the need for a USB cable between the GG and the computer to establish video communication and the absence of software for combined audio and video communication currently preclude its use in emergency settings. However, this technology is rapidly evolving, and software for Wi-Fi audio-video communication may soon become available.

This study should lead to further studies in two areas. Firstly, we need to improve understanding of the basic technical elements essential for communication between the intensivist and the first respondent, to enable intensivists to evaluate the cost-benefit ratio associated with each existing device. Future studies may compare audio-video and audio-only communication for in-hospital cardiac arrests, or audio-video communication via smartphones with that achieved with head-mounted devices, such as GG. We did not use the two-way video communication facility of GG (in our study, the remote intensivist could see what residents were seeing, but residents could not receive images or videos on their optical display). It would be interesting to determine whether such two-way video communication could improve CPR quality. CPR quality might be improved by the presentation on the GG display of written instructions concerning adrenaline dose, or very short educational videos or static images of compression and/or insufflation techniques, or even a complete pediatric CPR algorithm adapted for GG(26). However, this two-way video communication might prove to be more distracting than helpful, as observed here for two-way audio communication. A second axis of research would concern definition of the characteristics of communication between the intensivist and the first responder likely to improve patient outcomes. Human factors have been shown to affect the quality of CPR, but, to our knowledge, no study has compared different types of communication in resuscitation contexts(27).

Our study has several limitations. First, it included pediatric residents at the very start of their residency. Their lack of experience might account for their difficulties performing CPR whilst communicating with the intensivist and prescribing adrenaline. We might have obtained different results if we had recruited more experienced residents or physicians. However, we thought that the assistance of an intensivist via GG would be of greater benefit to less experienced health professionals, such as those included in our study. Second, residents were asked to manage a pCPA with the assistance of only one nurse, whereas in real-life conditions additional staff members might be available to help deal with cases of in-hospital pCPA. However, this should not have prevented them from performing insufflations and compressions. Finally, this was a simulation study and, as such, its results may not be generalizable to real-life conditions.

Conclusions

Due to their lack of experience, pediatrics residents provide suboptimal care in simulations of pCPA. This suboptimal care may decrease the patients' chances of survival. Real-time video communication between residents and an intensivist at a remote location via GG did not improve the no-blow and no-flow fractions, because speaking with the intensivist was associated with interruptions in CPR, particularly for adrenaline prescription. While there was no improvement on no-flow and no-blow fractions, GG led to better-quality insufflation and compression during the first five minutes of these simulated pCPAs.

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Tables

Table 1: Baseline characteristics of participants

Baseline characteristics	G. Glass *n* =21	Control *n* = 21	Total participants *n* = 42	Non-participants *n* = 30
Sex				
Male, *n* (%)	3 (14)	2 (10)	5 (12)	5 (17)
Female, *n* (%)	18 (86)	19 (90)	37 (88)	25 (83)
Rank in the national competitive examination, 2014				
< 2000/8304, *n* (%)	11 (52)	10 (48)	21 (50)	16 (54)
> 2000/8304, *n* (%)	10 (48)	11 (52)	21 (50)	14 (46)
Resuscitation training at medical school				
Basic life support, *n* (%)	14 (67)	15 (71)	29 (69)	26 (87)
Advanced cardiovascular life support, *n* (%)	1 (5)	0	1 (2)	1 (3)
Simulation resuscitation training, *n* (%)	16 (76)	17 (81)	33 (79)	25 (83)
Familiar with high-fidelity manikin, *n* (%)	8 (38)	9 (43)	17 (40)	10 (33)
Medical experience				
Cumulative length of pediatric rotations (months)[a]	4 (3-6)	4 (3-7)	4 (3-6)	4 (3-6)
Previous participation in CPA management, *n* (%)	11 (52)	10 (48)	21 (50)	18 (60)

G.Glass: Google Glass. a: Median (interquartile range).

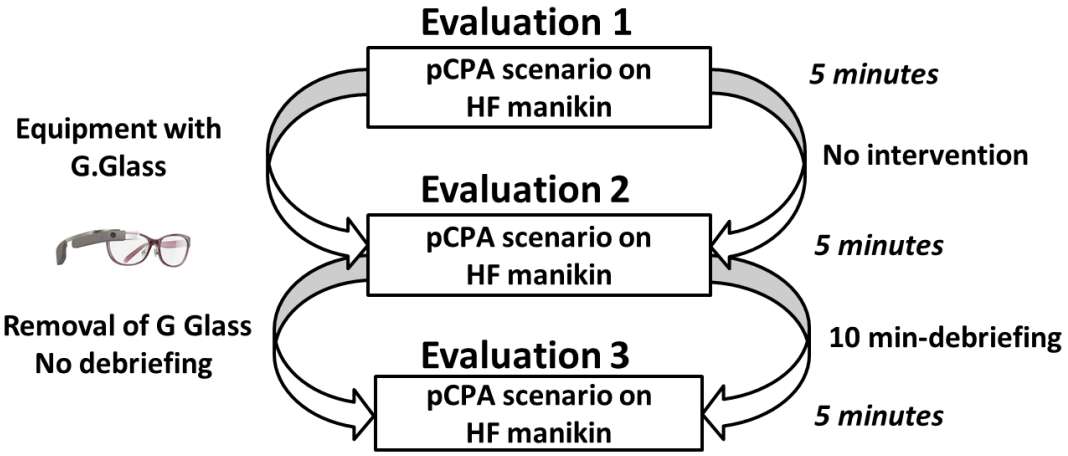
Table 2: Quality of life support

Resuscitation performance *n*=21 per group	G. Glass 1	Control 1	G. Glass 2	Control 2	*p*
Airways					
Suction of nasal secretions	8 (38%)	8 (38%)	21 (100%)	17 (81%)	0.11
Withdrawal of nasal prongs	7 (33%)	10 (48%)	20 (95%)	10 (48%)	0.001
Breathing					
Insufflation performed	20 (95%)	21 (100%)	21 (100%)	21 (100%)	1.00
Bag valve mask used [a]	19 (95%)	18 (86%)	21 (100%)	19 (90%)	0.49
Insufflation efficiency [a]	10 (50%)	12 (57%)	20 (95%)	14 (67%)	0.04
Time to first ventilation (s) [d]	118 (90-147)	101 (63-134)	68 (42-112)	82 (59-116)	0.64
Min-Max (s)	56-218	20-236	26-155	24-128	
No-blow fraction	81% (61-89)	66% (48-80)	49% (39-60)	53% (41-76)	0.28
Min-Max	45-100	17-100	25-78	30-92	
Circulation					
Compression performed	16 (76%)	16 (76%)	21 (100%)	21 (100%)	1.00
Correct hand positioning	10 (63%)	9 (56%)	21 (100%)	15 (71%)	0.02
Correct rate (100-120/min) [b]	9 (56%)	9 (56%)	19 (90%)	8 (38%)	<0.01
Time to first compression (s) [d]	165 (147-233)	121 (92-196)	122 (106-146)	108 (96-138)	0.33
Min-Max (s)	93-288	34-300	10-182	11-253	
No-flow fraction	92% (80-100)	98% (79-100)	68% (60-77)	73% (63-94)	0.28
Min-Max	56-100	68-100	55-100	35-100	
Intensivist called	5 (24%)	3 (14%)	21 (100%)	16 (76%)	0.048
Adrenaline					
Prescribed at some point	*na*	*na*	19 (90%)	21 (100%)	0.49
Correct dose [c]	*na*	*na*	16 (84%)	12 (57%)	0.09
Time to order (s) [c,d]	*na*	*na*	219 (208-227)	220 (198-249)	0.96
Min-Max	*na*	*na*	188-254	189-274	

a: among participants providing ventilation; b: among participants providing compressions ; c: among participants prescribing adrenaline; d: median (interquartile range).

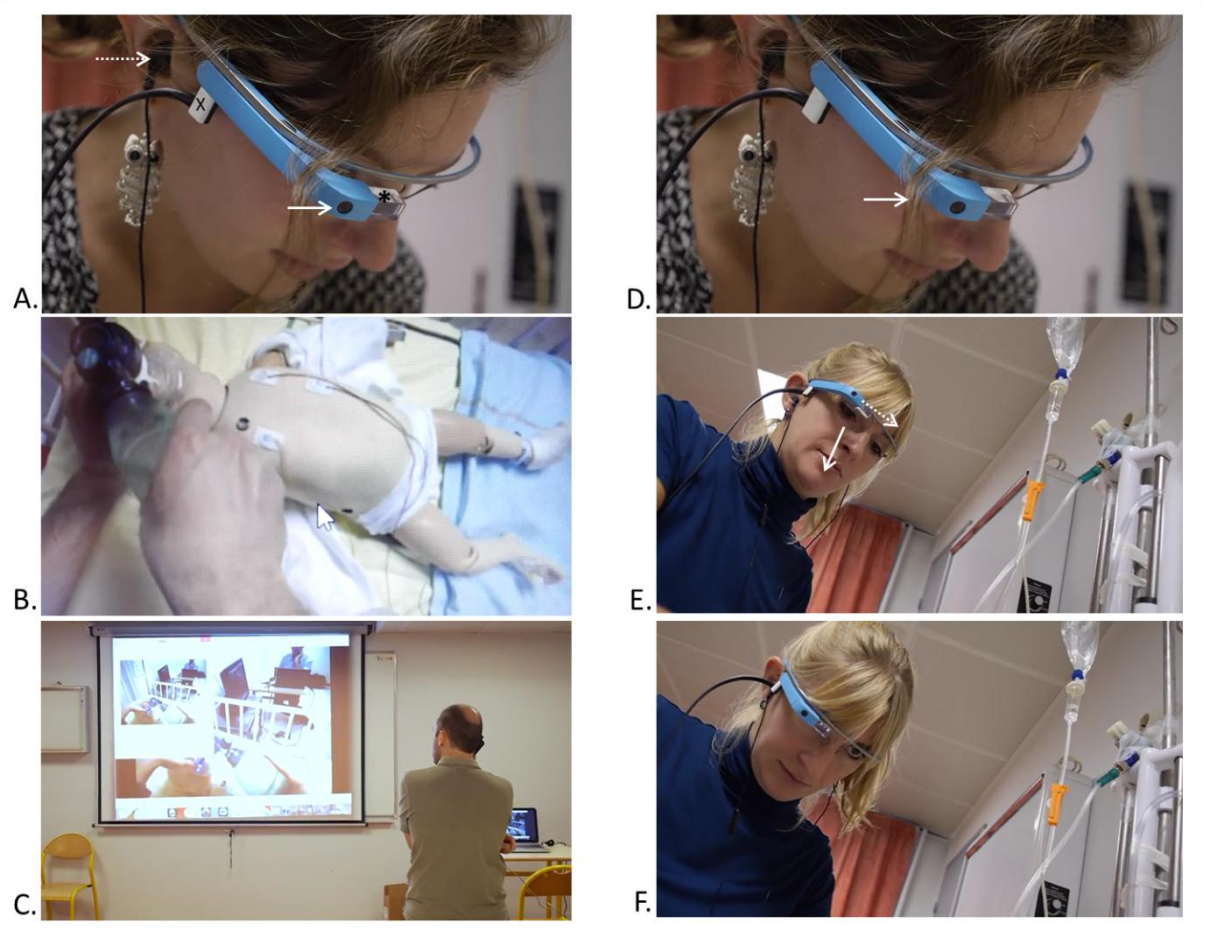
Figures

Figure 1: Study design



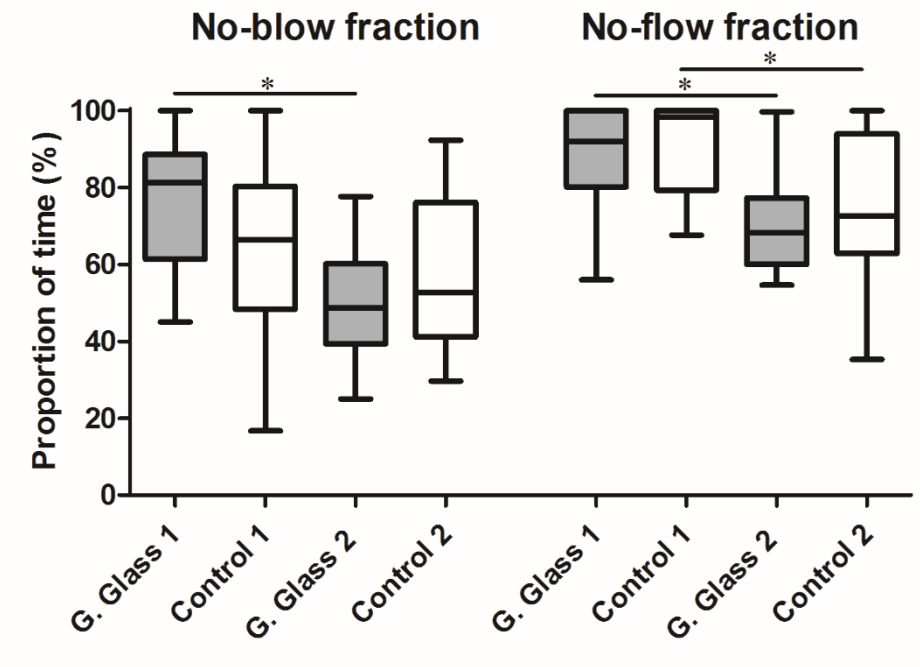
G Glass: Google Glass; pCPA: pediatric cardiopulmonary arrest; HF manikin: high-fidelity manikin.

Figure 2: Representative views of the experiment and of the technical limitations of Google Glass.



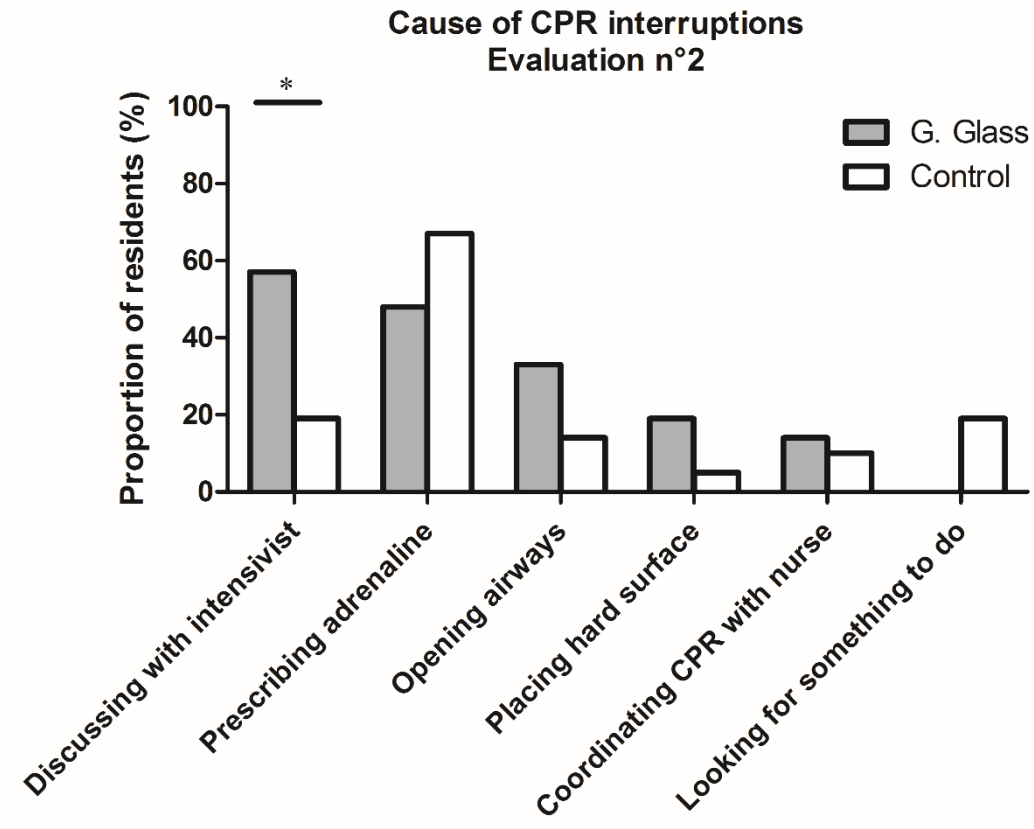
A. Google Glass (GG) includes a video camera (white arrow) and a display (*). The video link used a 20-meter USB cable (X), and the audio link used a hands-free kit (dashed white arrow) connected to an iPhone 4S. B. Representative view of the images sent to the intensivist, with the first-hand perspective provided by GG. C. The intensivist, in a separate room, guided the residents through the different steps of resuscitation.
Some technical limitations were noted with GG technology. D. The participant's hair may conceal the video camera. E. There may be a gap between what the participant is observing (plain white arrow) and the direction of the camera (dashed white arrow), resulting in a mismatch between what the participant and the intensivist are seeing. F. Correction of the gap after the intensivist asked to see the simulator.

Figure 3: No-blow and no-flow fractions



The thick horizontal lines represent the median values, and the lower and upper boundaries of the boxes indicate the interquartile range. The error bars encompass data points lying between the 2.5th to 97.5th percentiles. G.Glass: Google Glass. * $p < 0.05$.

Figure 4: Causes of CPR interruptions



CPR: cardiopulmonary resuscitation. G. Glass: Google Glass. *p<0.001

Supplemental Material

Table S1 : Simulation scenario

Stem

- An eight-month-old infant has been admitted for severe bronchiolitis in the night in the pediatric ward. The child was previously healthy, with an uneventful pregnancy and delivery on history. Immunizations up to date. There are no known allergies. His parents came home in the morning to take care of the siblings.
- The patient receives oxygen through nasal prongs 2L/min and fluids through an IV line at 32 mL/h (Mix of G5%, NaCl 3g/L and KCl 1g/L).
- At 9 am, after the transmissions, the participant hears the alarm of the patient's monitor, and decides to enter the room.

Scenario Stage	Patient Condition	Simulator Parameters	Expected intervention	Cues
Asystole 5 min	History • See above Weight : 8kg Condition : • Unconscious, unresponsive, apneic Physical Exam : • T 36.5, HR 0, RR 0, Sat n/a • Monitor : asystole • CNS : unconscious, no cry, eyes closed • CVS: no pulses palpable, cap refill 8 secs, mottled • Resp: no air entry bilaterally with no chest rise	Vitals • T 36.5 • HR 0 • RR 0 • Sat n/a • BP 20/P Condition • No palpable pulses • Cap Refill 8 secs	- Stimulate the child - Shout for help - Airway: • Open airway with head in neutral position, suction of nasal secretion, withdrawal of nasal prongs - Breathing: • Start bagging patient with 5 insufflations • Check that oxygen is linked to BMV • Check that chest rise - Circulation: • Initiation of chest compression • Alternate 15 compressions for 2 insufflations - Call the intensivist after 1 min of CPR	Cues: • Cao refill 8 seconds throughout • Mottled skin • Nasal secretions • IV access stays patent
End of the scenario after 5 minutes, with the arrival of the intensive care unit team.				

<table>
<tr><th>Scenario Stage</th><th>Patient Condition</th><th>Simulator Parameters</th><th>Expected intervention</th><th>Cues</th></tr>
<tr><td>Phase 1
Asystole
3 min</td><td>History
See above
Weight : 8kg
Condition :
Unconscious, unresponsive, apneic
Physical Exam :
T 36.5, HR 0, RR 0, Sat n/a
Monitor : asystole
CNS : unconscious, no cry, eyes closed
CVS: no pulses palpable, cap refill 8 secs, mottled
Resp: no air entry bilaterally with no chest rise</td><td>Vitals
T 36.5
HR 0
RR 0
Sat n/a
BP 20/P
Condition
No palpable pulses
Cap Refill 8 secs</td><td>- Stimulate the child
- Shout for help
- Airway:
Open airway with head in neutral position, suction of nasal secretion
- Breathing:
Start bagging patient with 5 insufflations
Check that oxygen is linked to BMV
Check that chest rise
- Circulation:
Initiation of chest compression
Alternate 15 compressions for 2 insufflations
- Call the intensivist after 1 min of CPR</td><td>Cues:
Cao refill 8 seconds throughout
Mottled skin
Nasal secretions
IV access stays patent</td></tr>
<tr><td rowspan="2">Phase 2
Asystole
2 min</td><td colspan="4">Entrance of the nurse in the 3rd minute</td></tr>
<tr><td>Idem</td><td>Idem</td><td>- Cooperation with the nurse for CPR
- Drugs : directs the preparation of adrenaline with the right dose</td><td>Idem</td></tr>
<tr><td colspan="5">End of the scenario after 5 minutes, with the arrival of the intensive care unit team.</td></tr>
</table>

Table S2 : Questionnaire on residents' characteristics.

French version filled by residents	Translated version in English
Quel est votre prénom?	What is your first name?
Quel est votre numéro d'étudiant?	What is your student number?
Etes-vous... - Un homme - Une femme	Are you… A male A female
Quel est votre classement aux épreuves classantes nationales ?	What was your rank in the national competitive examination?
Avez-vous passé une formation aux premiers secours pendant vos études médicales? - Oui - No	Did you attend resuscitation training at medical school? Yes No
Si OUI, laquelle ? - AFPS (attestation de formation aux premiers secours)/ PSC1 (prévention et secours civiques de niveau 1). - PSE1 (premiers secours en équipe de niveau 1)/PSE2 (premiers secours en équipe de niveau 2)	If YES, which one? - Basic life support - Advanced cardiovascular life support
Avez-vous déjà participé à une séance de réanimation sur simulateur ? - Oui - Non	Have you ever participated to a simulation resuscitation training? - Yes - No
Aviez-vous déjà fait de la simulation sur mannequin hautefidélité? - Oui - Non	Were you already familiar with high-fidelity manikins? Yes No
Combien de mois au total avez-vous passé en stage de pédiatrie ?	How many months (cumulated) did you spend in pediatric rotations?
Avez-vous déjà participé à la prise en charge d'un arrêt cardio-respiratoire? - Oui - Non	Have you ever participated in the management of a cardiac arrest? Yes No

Table S3 : Questionnaire on the impressions of residents regarding the use of Google Glass.

French version filled by residents	Translated version in English
Si vous avez eu les Google Gass, que diriez-vous de ce système ? - Cela m'a aidé dans la prise en charge de l'enfant - Cela ne m'a pas aidé dans la prise en charge de l'enfant - Cela m'a rassuré - Cela ne m'a pas rassuré - J'ai complètement oublié la partie matérielle du dispositif - La partie matérielle du dispositif m'a gêné	If you were in the Google Glass group, what did you think of this system? - It was helpful for the management of the child - It was not helpful for the management of the child - It was reassuring - It was not reassuring - I completely forgot the device - The device impeded the management of the patient

Table S4: No-blow and no-flow fractions: automatic vs manual record

	Automatic			Manual			Correlation	
n=21 per group	Glass 2	Control 2	*p*	Glass 2	Control 2	*p*	*Inter-rater correlation*	*Automatic vs manual*
No-blow fraction (%)	49 (39-60)	53 (41-76)	0.28	43 (38-49)	46 (39-54)	0.51	0.97 (0.96-0.98)	0.69 (0.48-0.83)
No-flow fraction (%)	68 (60-77)	73 (63-94)	0.28	66 (62-69)	60 (53-66)	0.08	0.99 (0.98-0.99)	0.37 (0.06-0.62)

Table S5: Reasons and duration of interruptions in cardiopulmonary resuscitation while discussing with the intensivist.

Reason and duration of interruption	G. Glass n=21	Control n=21	*p*
Explanation of the situation by the resident	4 (19%)	3 (14%)	1.00
• Duration of CPR interruption for each participant (s)	5;35;19;4	6;24;4	
Instructions on insufflation technique	3 (14%)	0	
• Duration of CPR interruption for each participant (s)	6;2;4	0	
Instructions on chest compression technique	2 (10%)	0	
• Duration of CPR interruption for each participant (s)	15;3	0	
Instructions on adrenaline prescription	4 (19%)	1 (5%)	
• Duration of CPR interruption for each participant (s)	5;2;11;2	6	
Instructions on placing a hard surface	2 (10%)	0	
• Duration of CPR interruption for each participant (s)	5;3	0	
Number of residents who interrupted CPR while listening to intensivist's instructions	10 (48%)	1 (5%)	0.004
Median duration of CPR interruption per participant (s)	2 (0-7.5)	0 (0-0)	0.02
• Min-Max	0-50	0-24	

CPR: Cardiopulmonary resuscitation

Figure S1: Study map