Can Video Assistance Improve the Quality of Pediatric Dispatcher-Assisted Cardiopulmonary Resuscitation?

Michael Peters, MHS, Samuel Stipulante, PhD, MHS,†‡ Véronique Cloes, MHS,* André Mulder, MD,§ Frédéric Lebrun, MD,§ Anne-Françoise Donneau, PhD,|| and Alexandre Ghuysen, PhD, MD*†*

Objectives: This study aimed to evaluate the impact of adding video conferencing to dispatcher-assisted telephone cardiopulmonary resuscitation (CPR) on pediatric bystander CPR quality.

Methods: We conducted a prospective, randomized manikin study among volunteers with no CPR training and among bachelor nurses. Volunteers randomly received either video or audio assistance in a 6-minute pediatric cardiac arrest scenario. The main outcome measures were the results of the Cardiff Test to assess compression and ventilation performance.

Results: Of 255 candidates assessed for eligibility, 120 subjects were randomly assigned to 1 of the 4 following groups: untrained telephone-guided (U-T; n = 30) or video-guided (U-V; n = 30) groups and trained telephone-guided (T-T; n = 30) or video-guided (T-V; n = 30) groups. Cardiac arrest was appropriately identified in 86.7% of the U-T group and in 100% in the other groups ($P = 0.0061$). Hand positioning was adequate in 76.7% of T-T, 80% of T-V, and 60% of U-V, as compared with 23.4% of the U-T group ($P = 0.0001$). Fewer volunteers managed to deliver 2 rescue breaths/cycle ($P = 0.0001$) in the U-T (16.7%) compared with the U-V (43.3%), the T-T (56.7%), and the T-V groups (60%).

Subjects in the video groups had a lower fraction of minute to ventilate as compared with the telephone groups ($P = 0.0005$).

Conclusions: In dispatcher-instructed children CPR simulation, using video assistance improves cardiac arrest recognition and CPR quality with more appropriate chest compression technique and ventilation delivering. The long interruptions in chest compression combined with the mixed success rate to deliver proper ventilation raise question about ventilation quality and its effectiveness.

Key Words: CPR, cardiac arrest, telephone, video

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Although less common than in adults, pediatric out-of-hospital cardiac arrest (OHCA) represents a major public health problem.[1,2] Despite well-established cardiopulmonary resuscitation (CPR) recommendations, the survival rate in pediatric cardiac arrest remains extremely low and associated with poor neurological outcomes.[3–6]

In this context, early recognition of cardiac arrest combine with early bystander CPR can improve survival and neurological outcomes.[3,4] The use of dispatcher-assisted telephone CPR (DA-CPR) to increase bystander CPR and survival has been well established in adults,[5–7] and now in pediatric cardiac arrest.[8,9] Traditionally, instructions are provided by telephone assistance. The development of telemedicine and new technologies such as mobile phone video applications may be an important area of research to improve communications between the rescuer and the emergency medical dispatch center. Several studies had already shown better CPR quality when video assistance was used rather than audio-assistance CPR.[10,11] However, it remains unclear whether video assistance can improve bystander performance in case of pediatric CPR combining chest compressions (CCs) with ventilation. This study was designed to compare the impact of video versus audio assistance on the quality of CPR initiated either by previously untrained or trained volunteers. We hypothesized that the quality of CPR and ventilations could be improved by using DA-CPR with video assistance.

From the *Department of Public Health, University of Liege; †Department of Emergency Medicine, University Hospital of Liege; ‡Federal Public Health Services; §Department of Paediatric Critical Care, Centre Hospitalier Chrétien of Liège; and ||Biostatistics Unit, Department of Public Health, University of Liege, Liege, Belgium.
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Reprints: Michael Peters, MHS, University of Liege, Liege, Belgium (e-mail: m.peters@chuliege.be); Alexandre Ghuysen, PhD, MD, University of Liege, Liege, Belgium (e-mail: a.ghuysen@chuliege.be).

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METHODS

Study Design

We conducted a prospective single-blind study using a pediatric cardiac arrest simulation model. The participants were randomly assigned to 1 of the 4 groups: untrained telephone-guided (U-T) or video-guided (U-V) groups and trained telephone-guided (T-T) or video-guided (T-V) groups.

The trial design was approved by the ethics committee of the University Hospital of Liege, Belgium (No. 2017/310).

Participants

Untrained participants between 18 and 75 years old were recruited in a movie theater in Liege (Belgium). Health care professionals, subjects with prior basic life support training, physical handicap, or significant cardiopulmonary disease, or those not speaking French were excluded from that group.

Previously trained volunteers were recruited among bachelor nurses pursuing certification either in pediatric or in emergency medicine from 3 high schools in Liege and Namur districts. The enrolled students undertook the same pediatric resuscitation training program a few months earlier.

Participants unwilling to participate in the study or sign their informed consent form were excluded.

Study Setting

According to the American Heart Association CPR guidelines[12] and based on the Belgium infant DA-CPR protocol,[13] expert group members developed a new children audio-guided and video-guided CPR protocols. These algorithms and their English translation are available at http://www.stipulante.com/ALERTPEDIA/Protocols.pdf.

Eight dispatchers from the Liege district were specifically trained for this protocol, to ensure acquisition of key skills. Operator's training included protocol presentation, opportunity to repeat each protocol, audio- and video-guided CPR individual coaching, and simulated case scenario. They were instructed to (i) strictly read the script during the test, (ii) use a metronome for CC delivering, and (iii) observe and correct if necessary hand positioning, CC depth and rate, and rescue breath delivering in case of video assistance.

Then, after reading a standardized scenario of a collapsed child on the ground, we dialed the emergency service number and told them to follow the instructions given by the operator. The test began as soon as the participant entered the room and in contact with the operator. Then, participants conducted 6 minutes of CPR using a child mannequin placed on the floor in a dedicated room. The volunteers were blinded to the results of the randomization before CPR started.

A free movie ticket was received by all the participants to minimize volunteering bias.

Outcome Measures and Data Collection

The trial was conducted using the pediatric manikin Resusci Junior QCPR with SkillGuide (Laerdal Medical, Stavanger, Norway). The CPR parameters and SkillGuide data were collected in the modified Cardiff test by 2 independent observers[14] using audio and video recordings. Volunteers were blinded from the SkillGuide feedback that was only visible by the camera. All volunteers used a smartphone (iPhone 6; Apple, Cupertino, Calif), connected via 4G cellular network to the FaceTime application for the video groups. For these groups, dispatchers used the same application on an IPad 2 (Apple).

The CPR quality parameters included initial check for responsiveness (asking for response and gently shake shoulders), check for breathing, hand positioning, CC depth (defined as ≥50 mm of depth), CC rate (defined as 100–120 compressions per minute), mouth-to-mouth ventilation delivering (defined as 2 ventilations given after each compressions cycles), and tidal volume (defined as 200–350 mL). All these variables were summed to compose a global CPR performance score, which was reported as 100.

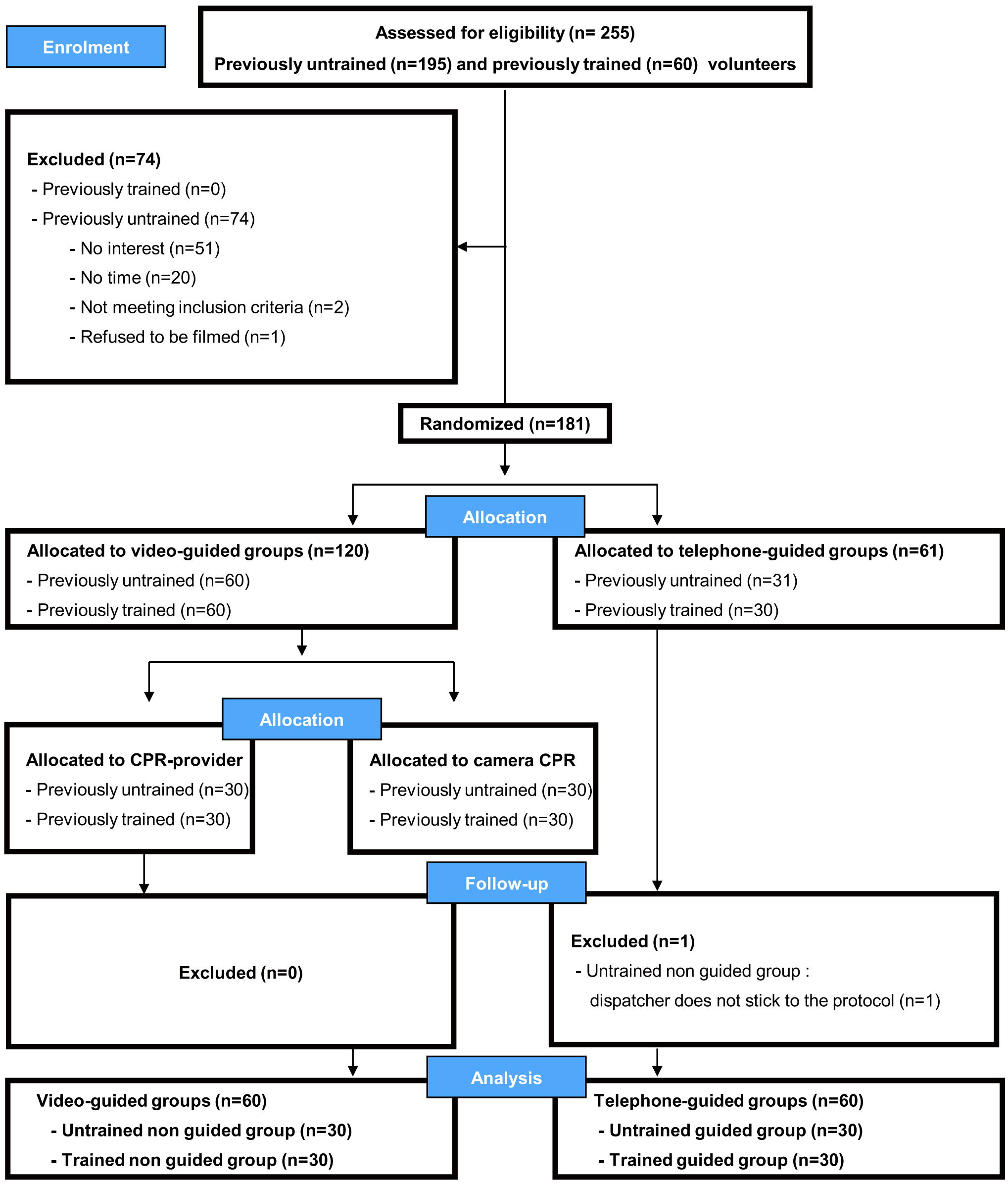

FIGURE 1. Participant flowchart.

The secondary outcome variables were total numbers of compressions and ventilations, mean compression rate (numbers per minute), time to check responsiveness, time to check breathing, time to first compression, time to first rescue breath, and CC fraction (percentage of time required for CC after the onset of CC).

Statistical Analysis

Normally distributed quantitative variables were summarized using means and SDs, whereas medians and 25th to 75th percentiles were considered for dissymmetric distributed quantitative variables. The normality was tested using the Shapiro-Wilk *W* test. Quantitative variables were compared between the 4 groups using a 1-way analysis of variance or Kruskal-Wallis test, followed by multiple comparison test if necessary. Qualitative variables were expressed using numbers and percentages and were compared between the 4 groups using χ^2 tests. Linear multiple regression analyses were applied to assess the impact of the volunteer's characteristics (age, sex, and previous education level) on the CPR performance score.

All results were considered to be significant at the 5% critical level ($P < 0.05$). Statistical analyses were carried out using SAS University Edition software.

RESULTS

Flow and Baseline Characteristics

Between April and June 2018, a total of 255 candidates were assessed for eligibility. Among these, 181 participants were randomly assigned in 1 of the 4 study groups according to the inclusion criteria (Fig. 1). Data from one volunteer were excluded from the untrained telephone-guided group because the dispatcher did not stick to the protocol.

As depicted in Table 1 and because of the nurses characteristics, the median age was significantly higher in the untrained groups (U-T, 37.5 [28–49]; U-V, 26.5 [22–45]) compared with the trained groups (T-T, 22 [22–24]; T-V, 22.5 [21–24]; $P < 0.0001$). In addition, there was a higher proportion of female and high education level in the trained guided groups ($P < 0.0001$).

CPR Performances

Initial Check for Responsiveness

Adequate check for responsiveness was better achieved in the 2 trained groups (T-T and T-V groups, 86.7%) compared with the U-V group (46.7%); the worst performance was noted in the U-T group (26.7%; $P < 0.0001$).

OHCA Recognition

Out-of-hospital cardiac arrest was recognized in 86.7% (26/30) of the U-T group, whereas 100% of the other groups identified OHCA appropriately ($P = 0.0061$; Table 2).

One hundred percent of the participants in the trained groups, 73.3% in the U-T group, and 80% in the U-V group identified the OHCA directly and gave a no-answer reply to the question "Is the child breathing normally?" (Fig. 2). Among all recognized and nonrecognized OHCA, 3 volunteers (10%) in the U-T group and 2 volunteers (6.7%) in the U-V group reported erroneously a breathing status with a yes-answer to the previous question, and 5 volunteers (16.7%) in the U-T group and 4 volunteers (13.3%) in the U-V group were not able to provide an answer to the dispatcher immediately.

In the U-V group, OHCA was eventually recognized by the dispatcher in 100% of cases with yes-answer (2/2) and unknown answer (4/4), whereas dispatcher identified OHCA in the U-T group in 0% (0/3) of calls with no answer and 80% (4/5) of calls with unknown answer.

Chest Compressions

Chest compression performances are reported in Table 2. There were significant differences between groups regarding the total number of compressions delivered ($P = 0.0016$). Indeed, the total number of CCs was significantly higher in the T-V group (214 [169–247]) compared with the T-T group (129 [119–209]), U-T group (119 [98–176]), and U-V group (149 [106–212]).

Chest compressions with adequate hands position were observed more frequently ($P = 0.0001$) in the trained groups (76.7% participants in the T-T group and 80% in the T-V group) and the U-V group (60%), as compared with the participants of the U-T group (23.4%).

The proportion of subjects performing adequate CC rate in the range 100/min to 120/min were similar between the groups

TABLE 1. Study Population Demographics

	Group				
	U-T (n = 30)	U-V (n = 30)	T-T (n = 30)	T-V (n = 30)	*P*
Age, y	37.5 (28–49)	26.5 (22–45)	22 (22–24)	22.5 (21–24)	<0.0001
Sex					<0.0001
Female, n (%)	15 (50.0)	10 (33.3)	28 (93.3)	28 (93.3)	
Previous education					<0.0001
No schooling, n (%)	2 (6.7)	2 (6.7)	0 (0)	0 (0)	
Grade school, n (%)	5 (16.7)	4 (13.3)	0 (0)	0 (0)	
Vocational school, n (%)	2 (6.7)	2 (6.7)	0 (0)	0 (0)	
Technical school, n (%)	3 (10)	6 (20)	0 (0)	0 (0)	
High school, n (%)	5 (16.7)	4 (13.3)	0 (0)	0 (0)	
Higher education, n (%)	13 (43.2)	12 (40)	30 (100)	30 (100)	
CPR realization experience, n (%)	4 (13.3)	3 (10)	26 (86.7)	22 (73.3)	<0.0001

TABLE 2. CPR Performance

	Group				
	U-T (n = 30)	**U-V (n = 30)**	**T-T (n = 30)**	**T-V (n = 30)**	***P***
Recognition of cardiac arrest, n (%)	26 (86.7)	30 (100)	30 (100)	30 (100)	0.0061
Total no. compressions delivered	119* (98–176)	149 (106–212)	129 (119–209)	214 (169–247)	0.0016
Adequate hands position, n (%)	7 (23.4)	18 (60.0)	23 (76.7)	24 (80.0)	0.0001
CC rate, n/min	114* (111–121)	114 (110–124)	111 (109–117)	112 (110–125)	0.44
Adequate CC depth, n (%)	14 (53.8)	16 (53.3)	8 (26.7)	12 (40)	0.12
Total no. rescue breath attempted	6* (6–12)	9.5 (6–15)	8 (6–12)	13.5 (10–15)	0.0003
Proportion of rescue breath effectively delivered, %	10* (0–43)	69.6 (33–100)	100 (50–100)	90 (67–100)	0.0001
Mouth-to-mouth ventilation delivering					0.0027
<2 rescue breath/cycle, n (%)	25 (83.3)	17 (56.7)	13 (43.3)	12 (40.0)	
2 rescue breath/cycle, n (%)	5 (16.7)	13 (43.3)	17 (56.7)	18 (60.0)	
Proportion of rescue breath with excessive tidal volume, %	86.1† (20–100)	100‡ (53.3–100)	100* (66.6–100)	93.3§ (55.5–100)	0.61
CPR score	47.2 (37.5–50.0)	50 (50.0–62.5)	62.5 (50.0–75.0)	62.5 (62.5–75.0)	<0.0001

*n = 26.
†n = 14.
‡n = 25.
§n = 27.

(60% participants in the U-T and U-V groups, 76.7% in the T-T group, 70% in the T-V group; $P = 0.4402$).

Ventilation Delivering

As shown in Table 2, the proportion of volunteers who managed to deliver 2 rescue breathes/cycle was significantly lower ($P = 0.0001$) in the U-T group (16.7%) than in the U-V group (43.3%), the T-T group (56.7%), and the T-V group (60%). Failure to deliver any ventilation was due to improperly opened airway (U-T, 33.3% [4/12]; V-T, 20% [1/5]; T-T, 25% [1/4]; T-V, 33.3% [1/3]) and leak during rescue breath (U-T, 66.7% [8/12]; V-T, 80% [4/5]; T-T, 75% [3/4]; T-V, 66.7% [2/3]).

However, none of the participants achieved to deliver 2 rescue breaths/cycle with adequate tidal volume, with a proportion of larger inflation volume similar in the 4 groups (U-T, 86.1% [20%–100%]; U-V, 100% [53.3%–100%]; T-T, 100 [66.6%–100%]; T-V group, 93.3 [55.5%–100%]; $P = 0.6090$).

Among all rescue breaths attempted, ventilations were effectively delivered ($P = 0.0001$) in 69.6% (33%–100%) of the U-T group, 100% (50%–100%) of the T-T group, and 90% (67%–100%) of the T-V group, but only in 10% (0%–43%) of the U-T group.

Global Performance Score

The median global CPR score differed significantly between the 4 groups (Table 2). The highest score was observed in the U-V group, T-T group, and T-V group, as compared with the U-T group. In addition, the global CPR score was significantly higher in the T-V group ($P = 0.0051$) than in the U-V group. There was no significant difference between the U-V and T-T groups, as well as between the T-T and T-V groups.

After adjusting for potential confounders, there was no significant difference between global CPR score and age, sex, or previous education level of the participants.

Time-Related Parameters

Time-related parameters are presented in Table 3. Median time to first CC and median time to first rescue breath were significantly longer in the U-V group than in the other groups ($P = 0.0001$ and $P < 0.0001$, respectively).

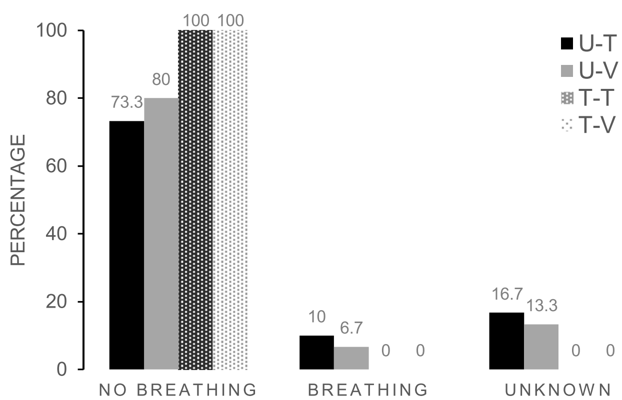

FIGURE 2. Reported breathing to the question "Is the child breathing normally?" ($P = 0.0111$).

Subjects from the video groups had a lower fraction of minute to ventilate (U-V, 62% [57.1%–70.8%]; T-V, 53.1% [50.4%–67.7%]) as compared with the telephone groups (U-T, 73.4% [67.3%–76.4%]; T-T, 73.6% [57.4%–76.7%]; *P* = 0.0005).

DISCUSSION

In this study of pediatric simulated cardiac arrest, we aimed to compare the CPR quality delivered by trained and untrained volunteers guided either by audio assistance or video assistance. Similarly to Lin et al,[10] who performed a systematic review comparing telephone versus video DA-CPR in adults and found that the quality of video assistance was superior to audio assistance regarding correct compression rates and hand positioning, we demonstrated that video assistance contribute to the improvement of OHCA recognition and CPR performances in case of dispatcher-instructed children CPR. Untrained volunteers with video assistance even reached similar global CPR performances to those of trained rescuers with audio assistance.

First, we found that dispatchers were able to appropriately identify 100% of cardiac arrest in case of video assistance, but only 86.7% in the U-T group. Adding video communication helped the dispatcher to detect a lack of breathing in the U-V group among volunteers who reported erroneously a breathing status in the manikin. Although early identification of cardiac arrest increases the bystander CPR rate and is a key factor in survival from OHCA,[12,15,16] a high proportion of children OHCA remain unidentified.[17–19] Several factors, such as presence of agonal breathing or conflicting information given by the caller, can contribute to negatively affect cardiac arrest recognition by the dispatcher.[15,20] Because of the visual connection and the immersion in the rescuer's reality, video conferencing could potentially help the dispatchers to properly identify cardiac arrest.

According to American Heart Association guidelines,[12] their simplified approach to assess breathing was adopted in our protocol, which allowed early recognition of cardiac arrest in 66 seconds (55–79 seconds) in the U-T group as compared with a 92.5-second delay (85–103 seconds) required to assess the infant breathing using the European Resuscitation Council technique.[13]

Cardiopulmonary resuscitation quality is associated with better survival outcomes.[12,21,22] Indeed, high-quality CC performances are determined by parameters such as adequate hand positioning, and adequate CC rate and depth.[23,24] In our cohort, the trained groups and U-V group achieved better results regarding hand positioning than did the U-T group. Stipulante and colleagues[11] also reported better hand positioning in the video group than in the telephone group, but in a higher proportion for both groups. This slight discrepancy could be explained by a higher sensibility of our children manikin as compared with the adult manikin, and by the higher threshold of acceptability used in this study. Because of the visual connection given by the camera, 33.3% of the U-V group received additional instructions by the dispatcher to reposition properly the hands of the callers. Thus, video assistance with visual feedback for the call taker offers the possibility to integrate a real-time CPR coaching and improve CPR quality.[25,26]

Whereas inadequate CC rate outside recommendations is common even for professional rescuers,[24,27] 60% of the subjects in the U-T and U-V groups, 76.7% in the T-T group, 70% in the T-V group achieved the recommended CC rate between 100 and 120 per minute.

In contrast to Lin et al,[10] who showed a significantly faster compression rate in the video-instructed method compared with the audio instruction, our results indicate a similar median compression rate in the range 100 to 120 per minute between the video and telephone groups. This divergent finding might be caused by a different metronome setting that was adjusted to 110 per minute in our study and by the pediatric feature of the study.

Performing high-quality CC remains difficult even for professional rescuers, with only 16% reaching the depth targets.[27] As described in a previous study,[11] our results confirm no positive effect of the video assistance over the telephone assistance on CC depth, with 53.9% of subjects of the U-T group performing appropriate depth target, 53.3% of the U-V group, 26.7% of the T-T group, and 40% of the T-V group (*P* = 0.1152).

Conventional CPR including CC combined with rescue breaths is recommended in case of pediatric OHCA.[12,28] Yang et al[29] demonstrated that the use of video communication even improved the quality of bystander rescue breathing in simulated adult cardiac arrest. In a study involving professional rescuers who used Google Glass in a simulated in-hospital infant cardiac arrest, adding real-time video communication likewise improved the effectiveness of the insufflations and CCs.[26] We also observed that ventilation was delivered more effectively in the video and trained groups, but noticed mixed results regarding the proportion of subjects who managed to effectively deliver 2 rescue breaths/cycle (U-T group, 16.7%; U-V group, 43.3%; T-T group, 56.7%; and T-V group, 60%; *P* = 0.0001). In addition, as described in previous reports,[13,30] we noted an excessive larger inflation volume delivered in all groups.

Minimizing pauses in CC is an essential quality CPR parameter,[12] with long interruptions in CC during CPR associated with a lower likelihood of survival.[31,32]

Morgan et al[33] showed that brief interruptions in CC for the delivery of rescue breath during pediatric in-hospital CPR have few hemodynamic effects. We observed that subjects in the video groups had a lower fraction of minute to ventilate as compared with the telephone groups. However, median CC fraction for each group remains extremely high (U-V, 62% [57.1%–70.8%]; T-V, 53.1% [50.4%–67.7%]; U-T, 73.4% [67.3%–76.4%]; T-T, 73.6%

TABLE 3. Time-Related Parameters

	Group				
	U-T (n = 30)	U-V (n = 30)	T-T (n = 30)	T-V (n = 30)	*P*
Responsiveness assessment, s	48 (41–51)	54 (45–64)	45 (42–50)	46 (41–53)	0.0488
Breathing assessment, s	66 (55–79)	72 (63–91)	62 (56–69)	61 (51–70)	0.0083
First CC, s	99* (91–110)	120 (102–136)	93 (86–103)	94 (81–103)	0.0001
First rescue breath, s	150 (135–166)	177 (152–204)	141 (131–156)	138 (127–153)	<0.0001
Fraction of time to ventilate, %	73.4* (67.3–76.4)	62.0 (57.1–70.8)	73.6 (57.4–76.7)	53.1 (50.4–67.7)	0.0005

*n = 26.

[57.4%–76.7%]) and situated well above the current recommendations of 20%. These mixed results regarding the proportion of ventilation delivering and excessive tidal volume combined with long CCs interruptions raise the question of the effectiveness of the ventilation during children CPR. Indeed, because of the prevalence of respiratory etiologies in pediatric OHCA, previous reports showed that conventional CPR was associated with improved outcomes and better survival results compared with CC-only CPR.[3,34,35] However, ventilation remains controversial because of the lack of evidence on the superiority of the conventional CPR over CC-only CPR in terms of 30-day neurologically intact survival.[36,37]

Survival after OHCA depends on time to initiate CPR with early CC and ventilation.[12,19,38] Regarding the timing of the first CC and first rescue breaths, we found that the U-V group spent more time to deliver the first compression and ventilation. As previously reported by Lin et al[10] and Yang et al,[29] similar delays were noted regarding first compression and first ventilation delivering in the video-assistance groups. However, because of the simplified approach adopted in our protocol to identify cardiac arrest, the delay in starting CPR was shorter in our study for the U-V group (120 seconds) compared with Stipulante et al,[11] who reported 146 seconds before first CC in an adult scenario. Interestingly, no difference in timing to first CC was observed between the T-V group and the T-T group. One possible explanation for this difference in timing between the 2 video groups might be attributed to the additional explanation required from the dispatcher to guide the U-V group as compared with the subjects of the T-V group who already knew the CPR procedure. The extra timing required before first CC in the U-T group should also be balanced with the benefit in CPR quality observed in this group.

This study has several limitations. First, this is a simulation study, which cannot exactly reproduce real-life and stress conditions representing barriers to bystander CPR.[39] Second, we were not able to precisely measure CC depth and tidal volume of the ventilations because of the manikin limitations. We also were not able to monitor duty cycle data, which represent a key factor to assess CPR quality.[40] Third, cardiac arrest recognition may be affected by the presence of agonal breathing,[20] which we could not reproduce in this study. Besides, the manikin's properties regarding chest and lung compliance are different and do not reflect reality adequately.[41]

We did not assess technical issues such as network connection and video quality related to transmission. Our study was conducted using a good Wi-Fi network, and more studies are needed to assess these potential technical issues for the CPR video assistance.

Finally, to minimize bias related to teaching and to constitute homogeneous guided groups with a higher level of skill reflecting the ideal rescuer, we selected candidates among bachelor nurses pursuing certification either in pediatric or in emergency medicine from 3 high schools. Although this sample does not reflect the characteristics of rescuers, we postulated that if video assistance was useful for these newly trained nurses, it could also be useful for less recently trained rescuers.

CONCLUSIONS

Using video assistance, compared with audio assistance in case of dispatcher-instructed children CPR, improve OHCA recognition and CPR quality with more appropriate CC technique and ventilation delivering. The long interruptions in CC combined with excessive tidal volume and intermediate success rate to deliver ventilations raise the question about the quality of ventilation and its effectiveness. Further investigations are needed to assess the quality and effects of ventilation in children CPR.

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