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Contents

Thrice Monthly Volume 10 Number 31 November 6, 2022

REVIEW

11214 Diabetes and skin cancers: Risk factors, molecular mechanisms and impact on prognosis

Dobrică EC, Banciu ML, Kipkorir V, Khazeei Tabari MA, Cox MJ, Simhachalam Kutikuppala LV, Găman MA

11226 Endocrine disruptor chemicals as obesogen and diabetogen: Clinical and mechanistic evidence

Kurşunoğlu NE, Sarer Yurekli BP

11240 Intestinal microbiota in the treatment of metabolically associated fatty liver disease

Wang JS, Liu JC

MINIREVIEWS

11252 Lactation mastitis: Promising alternative indicators for early diagnosis

Huang Q, Zheng XM, Zhang ML, Ning P, Wu MJ

11260 Clinical challenges of glycemic control in the intensive care unit: A narrative review

Sreedharan R, Martini A, Das G, Aftab N, Khanna S, Ruetzler K

11273 Concise review on short bowel syndrome: Etiology, pathophysiology, and management

Lakkasani S, Seth D, Khokhar I, Touza M, Dacosta TJ

11283 Role of nickel-regulated small RNA in modulation of *Helicobacter pylori* virulence factors

Freire de Melo F, Marques HS, Fellipe Bueno Lemos F, Silva Luz M, Rocha Pinheiro SL, de Carvalho LS, Souza CL, Oliveira MV

11292 Surgical intervention for acute pancreatitis in the COVID-19 era

Su YJ, Chen TH

ORIGINAL ARTICLE

Clinical and Translational Research

11299 Screening of traditional Chinese medicine monomers as ribonucleotide reductase M2 inhibitors for tumor treatment

Qin YY, Feng S, Zhang XD, Peng B

Case Control Study

11313 Covered transjugular intrahepatic portosystemic stent-shunt *vs* large volume paracentesis in patients with cirrhosis: A real-world propensity score-matched study

Dhaliwal A, Merhzad H, Karkhanis S, Tripathi D

Retrospective Cohort Study

11325 Endoscopic submucosal tunnel dissection for early esophageal squamous cell carcinoma in patients with cirrhosis: A propensity score analysis

Zhu LL, Liu LX, Wu JC, Gan T, Yang JL

Retrospective Study

11338 Nomogram for predicting overall survival in Chinese triple-negative breast cancer patients after surgery

Lin WX, Xie YN, Chen YK, Cai JH, Zou J, Zheng JH, Liu YY, Li ZY, Chen YX

11349 Early patellar tendon rupture after total knee arthroplasty: A direct repair method

Li TJ, Sun JY, Du YQ, Shen JM, Zhang BH, Zhou YG

11358 Coxsackievirus A6 was the most common enterovirus serotype causing hand, foot, and mouth disease in Shiyan City, central China

Li JF, Zhang CJ, Li YW, Li C, Zhang SC, Wang SS, Jiang Y, Luo XB, Liao XJ, Wu SX, Lin L

11371 Dynamic changes of estimated glomerular filtration rate are conversely related to triglyceride in non-overweight patients

Liu SQ, Zhang XJ, Xue Y, Huang R, Wang J, Wu C, He YS, Pan YR, Liu LG

11381 C-reactive protein as a non-linear predictor of prolonged length of intensive care unit stay after gastrointestinal cancer surgery

Yan YM, Gao J, Jin PL, Lu JJ, Yu ZH, Hu Y

Clinical Trials Study

11391 Dan Bai Xiao Formula combined with glucocorticoids and cyclophosphamide for pediatric lupus nephritis: A pilot prospective study

Cao TT, Chen L, Zhen XF, Zhao GJ, Zhang HF, Hu Y

Observational Study

11403 Relationship between lipids and sleep apnea: Mendelian randomization analysis

Zhang LP, Zhang XX

11411 Efficacy and safety profile of two-dose SARS-CoV-2 vaccines in cancer patients: An observational study in China

Cai SW, Chen JY, Wan R, Pan DJ, Yang WL, Zhou RG

Prospective Study

11419 Pressure changes in tapered and cylindrical shaped cuff after extension of head and neck: A randomized controlled trial

Seol G, Jin J, Oh J, Byun SH, Jeon Y

Randomized Controlled Trial

11427 Effect of intradermal needle therapy at combined acupoints on patients' gastrointestinal function following surgery for gastrointestinal tumors

Guo M, Wang M, Chen LL, Wei FJ, Li JE, Lu QX, Zhang L, Yang HX

SYSTEMATIC REVIEWS

11442 Video-assisted bystander cardiopulmonary resuscitation improves the quality of chest compressions during simulated cardiac arrests: A systemic review and meta-analysis

Pan DF, Li ZJ, Ji XZ, Yang LT, Liang PF

META-ANALYSIS

11454 Efficacy of the femoral neck system in femoral neck fracture treatment in adults: A systematic review and meta-analysis

Wu ZF, Luo ZH, Hu LC, Luo YW

11466 Prevalence of polymyxin-induced nephrotoxicity and its predictors in critically ill adult patients: A meta-analysis

Wang JL, Xiang BX, Song XL, Que RM, Zuo XC, Xie YL

CASE REPORT

11486 Novel compound heterozygous variants in the LHX3 gene caused combined pituitary hormone deficiency: A case report

Lin SZ, Ma QJ, Pang QM, Chen QD, Wang WQ, Li JY, Zhang SL

11493 Fatal bleeding due to an aorto-esophageal fistula: A case report and literature review

Ćeranić D, Nikolić S, Lučev J, Slanič A, Bujas T, Ocepek A, Skok P

11500 Tolvaptan ameliorated kidney function for one elderly autosomal dominant polycystic kidney disease patient: A case report

Zhou L, Tian Y, Ma L, Li WG

11508 Extensive right coronary artery thrombosis in a patient with COVID-19: A case report

Dall'Orto CC, Lopes RPF, Cancela MT, de Sales Padilha C, Pinto Filho GV, da Silva MR

11517 Yokoyama procedure for a woman with heavy eye syndrome who underwent multiple recession-resection operations: A case report

Yao Z, Jiang WL, Yang X

11523 Rectal cancer combined with abdominal tuberculosis: A case report

Liu PG, Chen XF, Feng PF

11529 Malignant obstruction in the ileocecal region treated by self-expandable stent placement under the fluoroscopic guidance: A case report

Wu Y, Li X, Xiong F, Bao WD, Dai YZ, Yue LJ, Liu Y

11536 Granulocytic sarcoma with long spinal cord compression: A case report

Shao YD, Wang XH, Sun L, Cui XG

11542 Aortic dissection with epileptic seizure: A case report

Zheng B, Huang XQ, Chen Z, Wang J, Gu GF, Luo XJ

11549 Multiple bilateral and symmetric C1-2 ganglioneuromas: A case report

Wang S, Ma JX, Zheng L, Sun ST, Xiang LB, Chen Y

11555 Acute myocardial infarction due to Kounis syndrome: A case report

Xu GZ, Wang G

11561 Surgical excision of a large retroperitoneal lymphangioma: A case report

Park JH, Lee D, Maeng YH, Chang WB

11567 Mass-like extragonadal endometriosis associated malignant transformation in the pelvis: A rare case report

Chen P, Deng Y, Wang QQ, Xu HW

11574 Gastric ulcer treated using an elastic traction ring combined with clip: A case report

Pang F, Song YJ, Sikong YH, Zhang AJ, Zuo XL, Li RY

11579 Novel liver vein deprivation technique that promotes increased residual liver volume (with video): A case report

Wu G, Jiang JP, Cheng DH, Yang C, Liao DX, Liao YB, Lau WY, Zhang Y

11585 Linear porokeratosis of the foot with dermoscopic manifestations: A case report

Yang J, Du YQ, Fang XY, Li B, Xi ZQ, Feng WL

11590 Primary hepatic angiosarcoma: A case report

Wang J, Sun LT

11597 Hemorrhagic shock due to ruptured lower limb vascular malformation in a neurofibromatosis type 1 patient: A case report

Shen LP, Jin G, Zhu RT, Jiang HT

11607 Gastric linitis plastica with autoimmune pancreatitis diagnosed by an endoscopic ultrasonography-guided fine-needle biopsy: A case report

Sato R, Matsumoto K, Kanzaki H, Matsumi A, Miyamoto K, Morimoto K, Terasawa H, Fujii Y, Yamazaki T, Uchida D, Tsutsumi K, Horiguchi S, Kato H

11617 Favorable response of primary pulmonary lymphoepithelioma-like carcinoma to sintilimab combined with chemotherapy: A case report

Zeng SY, Yuan J, Lv M

11625 Benign paroxysmal positional vertigo with congenital nystagmus: A case report

Li GF, Wang YT, Lu XG, Liu M, Liu CB, Wang CH

11630 Secondary craniofacial necrotizing fasciitis from a distant septic emboli: A case report

Lee DW, Kwak SH, Choi HJ

11638 Pancreatic paraganglioma with multiple lymph node metastases found by spectral computed tomography: A case report and review of the literature

Li T, Yi RQ, Xie G, Wang DN, Ren YT, Li K

11646 Apnea caused by retrobulbar anesthesia: A case report

Wang YL, Lan GR, Zou X, Wang EQ, Dai RP, Chen YX

11652 Unexplained septic shock after colonoscopy with polyethylene glycol preparation in a young adult: A case report

Song JJ, Wu CJ, Dong YY, Ma C, Gu Q

11658 Metachronous isolated penile metastasis from sigmoid colon adenocarcinoma: A case report

Yin GL, Zhu JB, Fu CL, Ding RL, Zhang JM, Lin Q

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SYSTEMATIC REVIEWS

Video-assisted bystander cardiopulmonary resuscitation improves the quality of chest compressions during simulated cardiac arrests: A systemic review and meta-analysis

Dong-Feng Pan, Zheng-Jun Li, Xin-Zhong Ji, Li-Ting Yang, Pei-Feng Liang

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Abstract

BACKGROUND

It remains unclear whether video aids can improve the quality of bystander cardiopulmonary resuscitation (CPR).

AIM

To summarize simulation-based studies aiming at improving bystander CPR associated with the quality of chest compression and time-related quality parameters.

METHODS

The systematic review was conducted according to the PRISMA guidelines. All relevant studies were searched through PubMed, EMBASE, Medline and Cochrane Library databases. The risk of bias was evaluated using the Cochrane collaboration tool.

RESULTS

A total of 259 studies were eligible for inclusion, and 6 randomised controlled trial studies were ultimately included. The results of meta-analysis indicated that video-assisted CPR (V-CPR) was significantly associated with the improved mean chest compression rate [OR = 0.66 (0.49-0.82), P < 0.001], and the proportion of chest compression with correct hand positioning [OR = 1.63 (0.71-2.55), P < 0.001]. However, the difference in mean chest compression depth was not statistically significant [OR = 0.18 (-0.07-0.42), P = 0.15], and V-CPR was not associated with the time to first chest compression compared to telecommunicator CPR [OR = -0.12 (-0.88-0.63), P = 0.75].

CONCLUSION

Video real-time guidance by the dispatcher can improve the quality of bystander CPR to a certain extent. However, the quality is still not ideal, and there is a lack of guidance caused by poor video signal or inadequate interaction.

Key Words: Dispatcher-assisted cardiopulmonary resuscitation; Video; Quality of chest compressions; Simulated cardiac arrests

Core Tip: This study conducted a systemic review and meta-analysis to summarized the outcomes of training programs aimed at improving bystander cardiopulmonary resuscitation associated with the quality of chest compressions and time-related quality parameters.

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INTRODUCTION

Although the likelihood of survival with cardiac arrest (CA) is increasing, CA has emerged as the leading cause of death worldwide[1,2]. A meta-analysis showed that the aggregate survival rate of hospital discharge of adult patients with cardiac arrest (OHCA) was only 7.6%, which remained stable over the past 30 years[3]. Immediate cardiopulmonary resuscitation (CPR) is the most effective measure to improve the prognosis of patients with CA[4]. Studies have shown that the first witness's CPR can double the survival rate of patients with OHCA[5]. Generally, the patient’s family members are most likely to witness the occurrence of CA, and they are more willing to perform CPR on the spot. However, most CA witnesses are lacking life support knowledge and have not received any CPR training. Thus, they are not able to perform on-site CPR for patients with CA. An effective way to fill such short-comings is that the dispatcher who receives emergency calls should guide the witnesses to perform CPR on the spot by telephone, that is, the dispatcher uses telephone or video facilities to improve dispatcher-assisted CPR (DA-CPR).

DA-CPR has been widely carried out in European and American countries[6]. It has been proven that DA-CPR can increase the quality of CPR performed by the first witnesses[7] and improve the survival rate of victims with CA[8,9]. In 2015, the American Heart Association (AHA) included DA-CPR in the guidelines for cardiopulmonary resuscitation for the first time[10]. Many emergency medical service systems have established verbal CPR instructions to help callers cope with CPR. However, the quality of DA-CPR is still not ideal[11,12]. Although many efforts have been made to improve the quality of DA-CPR by modifying the command protocol, its actual effect is still not satisfactory[13-16].

The communication method of DA-CPR guidance is usually based on voice and telephone guidance. As a result, the quality of CPR performed by bystanders cannot be intuitively controlled, and a low-quality CPR is more likely to occur. Low-quality CPR may not improve the prognosis of patients with CA. Therefore, improving the quality of bystander CPR has become a focus of attention in recent years. With the advancement of wireless telecommunications, the introduction of video phones enables simultaneous voice and video commands. Video guidance *via* mobile phones can be a powerful tool for CPR guidance in emergency situations. For example, bystanders call CPR guidance and receive real-time voice instructions and video demonstrations *via* mobile phones, such as video self-learning programs. At the same time, the CPR performance of bystanders can be monitored and fed back to the dispatcher. Some preliminary studies have evaluated the possibility of applying video link instructions to improve the quality of bystander CPR[17], and the effect of video-assisted CPR (V-CPR) training has been extensively studied. Video self-learning procedures or video-based instructions have been documented to have more or at least as effective CPR training than conventional training methods[18-24]. However, the outcomes associated with V-CPR during simulated CAs remain unclear and await further study.

To address this issue, we conducted a systematic review and meta-analysis of quantitative studies to assess the effectiveness of video-assisted and telephone-assisted CPR in increasing chest compression rates during simulated CAs. The outcomes of training programs aimed at improving bystander CPR, including the quality of chest compression and time-related quality parameters, were analyzed in this study.

MATERIALS AND METHODS

Inclusion and exclusion criteria

To answer the PICOS question, the inclusion criteria for our systematic review were as follows:

P: Subjects were adult volunteers or high school students, without any previous CPR training.

I: Intervention is a dispatcher initiated standardized video-guided CPR.

C: Control group dispatcher initiated standardized telephone-guided CPR.

O: Outcome indicators were: (1) The quality of chest compression, including the mean compression rate, the number of subjects who performed an adequate compression rate, the mean compression depth (between 5 and 6 cm), the number of subjects who performed an adequate compression depth, and adequate positioning of hands (on the lower half of the sternum); and (2) Time-related quality parameters, including time to initiate continuous compression, and total hands-off time (the pause between compressions longer than 1.5 s).

S: Research design is randomized simulation-based studies. We did not consider articles published in non-English journals, repetitive publications, no relevant outcome indicators, and unavailable or incomplete original data.

Literature search strategy

We searched PubMed, EMBASE, Medline, and Cochrane Library databases for studies published between the establishment time of the database to May 2021. The following search terms were used: “heart arrest”, “cardiopulmonary resuscitation”, “cardiac arrest” and “video-assisted”, “telephone-assisted”, “dispatcher-assisted”, *etc.* Take PubMed as a working example, Box 1 Lists the specific search strategy. In addition, we manually checked the reference list of each article for further appropriate studies.

Data extraction

Two researchers independently screened the articles, extracted data, and cross-checked them. If there is a disagreement, it will be resolved through discussion or negotiation with a third party. After excluding the irrelevant documents, the abstract and full text of each article were thoroughly read to determine its eligibility. If necessary, the authors of an original research article will be contacted *via* email or telephone to obtain the missing information. The following data were extracted: (1) Basic information of the included studies, including research titles, first authors, published journals, *etc.*; (2) Baseline characteristics and intervention measures of the research object; (3) Key elements of the risk of bias evaluation; and (4) Outcome measures and performance indicators.

Risk of bias assessment

Two investigators independently evaluated the risk of bias for the included studies and cross-checked the results. The Cochrane handbook version 5.1.0 was used for assessing the risk of bias.

Statistical analysis

Meta-analysis was conducted with version 13.0 Stata software. The count data were analyzed by calculating the odds ratio (OR) and its 95% confidence interval (CI). The measurement data involved different research types and measurement methods. Thus, the standardized mean difference was used as an effect indicator, and each effect size was given a point. The heterogeneity among the included studies was analyzed by the χ^2 test (α = 0.1), and the I^2 statistic was used to quantitatively judge the size of the heterogeneity. If there was no statistical heterogeneity, the fixed-effects model was used for interpreting the meta-analysis results; otherwise, the random-effects model was chosen and the source of the heterogeneity was further analyzed. Meanwhile, obvious clinical heterogeneity was analyzed descriptively.

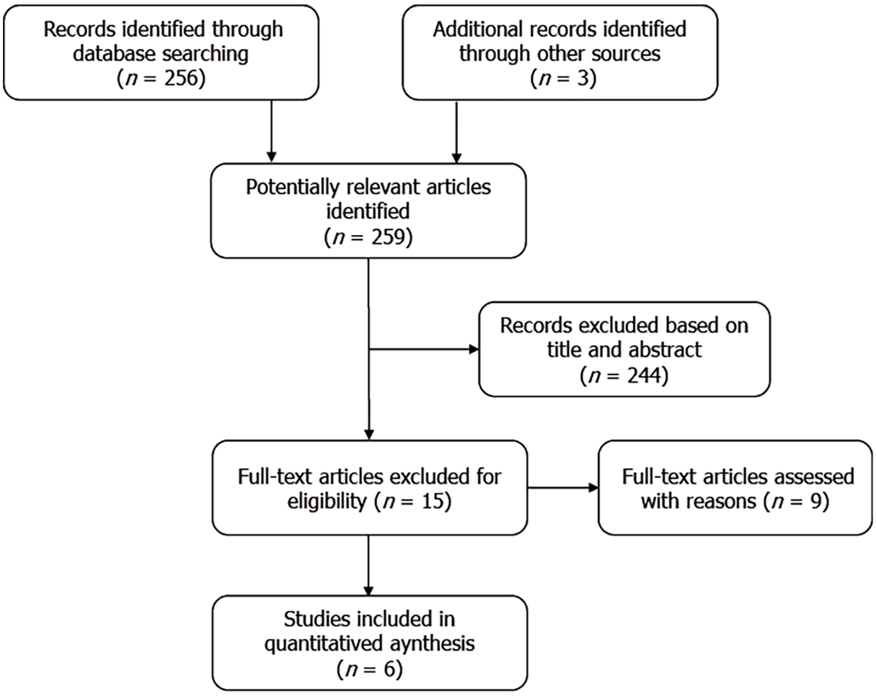

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Figure 1 The flow diagram of the study selection.

RESULTS

Study selection and risk of bias

A total of 259 relevant articles were retrieved by searching the online databases. Six studies[25], involving 537 volunteers, were included after layer-by-layer screening. The flow diagram of the study selection is illustrated in Figure 1. The basic characteristics of the included studies are demonstrated in Table 1. The results of the risk of bias assessment are shown in Figure 2.

The quality of chest compression

The mean chest compression rate was reported in all six studies involving 537 volunteers[25]. The results of the fixed-effects inverse-variance model indicated that video-guided CPR was significantly associated with the improved mean chest compression rate [OR = 0.66, 95%CI: 0.49-0.82, P < 0.001] (Figure 3A). The weighted mean chest compression rate increased from 92.01 min^{-1} in telecommunicator CPR (T-CPR) group to 105.62 min^{-1} in V-CPR group.

The mean chest compression depth was reported in all six studies (25-30) involving 537 volunteers. The results of random-effects REML model showed that the difference in the mean chest compression depth between the two groups was not statistically significant [OR = 0.18, 95%CI: -0.07-0.42, P = 0.15] (Figure 3B). The proportion of chest compression with correct hand positioning was reported in all six studies. However, four studies set this indicator as a continuous variable and the other two studies set as the dichotomous variables[26,27]. The first four studies included 382 volunteers, and the results of random-effects REML model indicated that no significant difference was found between the T-CPR and V-CPR groups [OR = 0.24, 95%CI: -0.33-0.82, P = 0.41] (Figure 3C). The last two studies included 155 volunteers, and the results of random-effects REML model indicated that V-CPR was significantly associated with the improved proportion of chest compression with correct hand positioning [OR = 1.63, 95%CI: 0.71-2.55, P < 0.001] (Figure 3C).

There was obvious statistical heterogeneity in the number of subjects who performed adequate chest compression and the proportion of chest compression with appropriate depth. Thus, a qualitative description was provided. Three out of the four studies[26-28] demonstrated that the number of subjects who performed adequate chest compression was significantly higher in V-CPR group than in T-CPR group. One out of the five studies[28] indicated that the proportion of chest compression with appropriate depth in V-CPR was significantly greater than that in T-CPR group.

Time-related quality parameters

Time to first chest compression was reported in five studies[25] involving 480 volunteers. The results of random-effects REML model showed that V-CPR was not associated with the time to first chest compression compared to T-CPR[OR = -0.12, 95%CI: -0.88-0.63, P = 0.75] (Figure 4).

Table 1 The characteristics of included studies

Ref.	Loction	Study period	Subjects	Number of Subjects		Scenarios duration	Experiment procedure		Assessment
				V-CPR	T-CPR		V-CPR	T-CPR	
Lee *et al* [25], 2021	Korea	October 2019 to July 2020	Volunteers aged 18 years or older	88	43	6 min	Video call transition was performed after initiation of by stander chest compression	The dispatcher uses a standard audio instructed protocol to help the participant initiate and perform chest compression-only CPR	(1) The mean proportion of ade quate hand positioning during chest compressions; (2) The mean compres sion depth; (3) Mean compression rate; and (4) Total no-flow time
Yang *et al* [26], 2009	Taiwan	-	Volunteers above 16 years of age who have not received any CPR training within the last 5 years	43	53	4 min	Received interactive voice and video demonstration and feedback *via* a video cell phone	Received only voice CPR instruction	(1) Chest compressions rate; (2) Chest compressions depth; (3) Proportion of subjects with sufficient rate; (4) Proportion of chest compressions with appropriate depth; (5) Proportion of correct hand positioning; (6) Hands-off time; (7) Time to first chest compression; and (8) Total duration of CPR instructions
Ecker *et al* [27], 2020	Cologne	July to August 2018	Adult volunteer, lay people without any previous CPR training	50	50	8 min	The study assistant operated the camera function of the phone, volunteers activated EmergencyEye and started standardised video guided CPR	The study assistant enabled the phone's speaker function, the EMS dispatcher then initiated standardised telephone guided CPR	(1) Compression frequency 100 to 120 min–1; (2) Ccompression depth 5 to 6 cm; and (3) Correct hand position on the lower third of the sternum
Lee *et al* [28], 2011	Korea	May 2010 to June 2010	Adult volunteer,lay people without any previous CPR training	39	39	5 min	Instructed to make a voice call to a number, guided on how to play a video stored on the phone, and were further asked to do as shown on the video until the emergency medical technicians arrived	Instructed to make a phone call to the same number, where they were guided by a dispatcher using the standardised protocol to perform compression-only CPR	(1) The mean compression rate; (2) The number of subjects who performed an adequate compression rate; (3) The mean compression depth; (4) The number of subjects who performed an adequate compression depth; (5) Adequate positioning of hands; (6) Time to initiate continuous compressions; (7) Hands-off time; and (8) The number of subjects who had no "hands-off" event after starting compressions
Stipulante *et al*[29], 2016	Belgium	March 2013	High school Students volunteers, 16-25	60	60	8 min	Developed an original protocol of videocon-ference CPR instructions on the basis of the ALERT algorithm, followed the dispatcher's instructions and performed CPR	Guided according to the ALERT protocol, given the instruction to 'put the speaker on' and to 'put the phone down' to receive further instruction	(1) Rate of chest compressions; (2) Total number of chest compressions; (3) Depth of chest compressions; (4) Proportion of chest compressions with appropriate rate; (5) Proportion of chest compression with appropriate depth; (6) Proportion of chest compressions with correct hand positioning; (7) Time for respons-iveness check; (8) Time

									for airway opening; (9) Time for breathing check; (10) Time to first compression; and (11) Hands-off time
Bolle *et al* [30], 2009	Norway	December 2006 and January 2007	High-school students	29	26	10 min	Dispatchers used a lap_x0002_top with a UMTS (3G) card, video camera, videocommu-nication software and a standard headset	Dispatchers used a telephone with a standard headset	(1) Total number of compressions; (2) Average depth (mm); (3) Average rate (n/min); (4) Average number per minute; (5) Proportion done without error; (6) Proportion done to correct depth; (7) Proportion with correct hand position; (8) Proportion done with full release; (9) Time to first compression (s); and (10) Total hands-off-chest time (s)

V-CPR: Video-assisted cardiopulmonary resuscitation; T-CPR: Telecommunicator cardiopulmonary resuscitation.

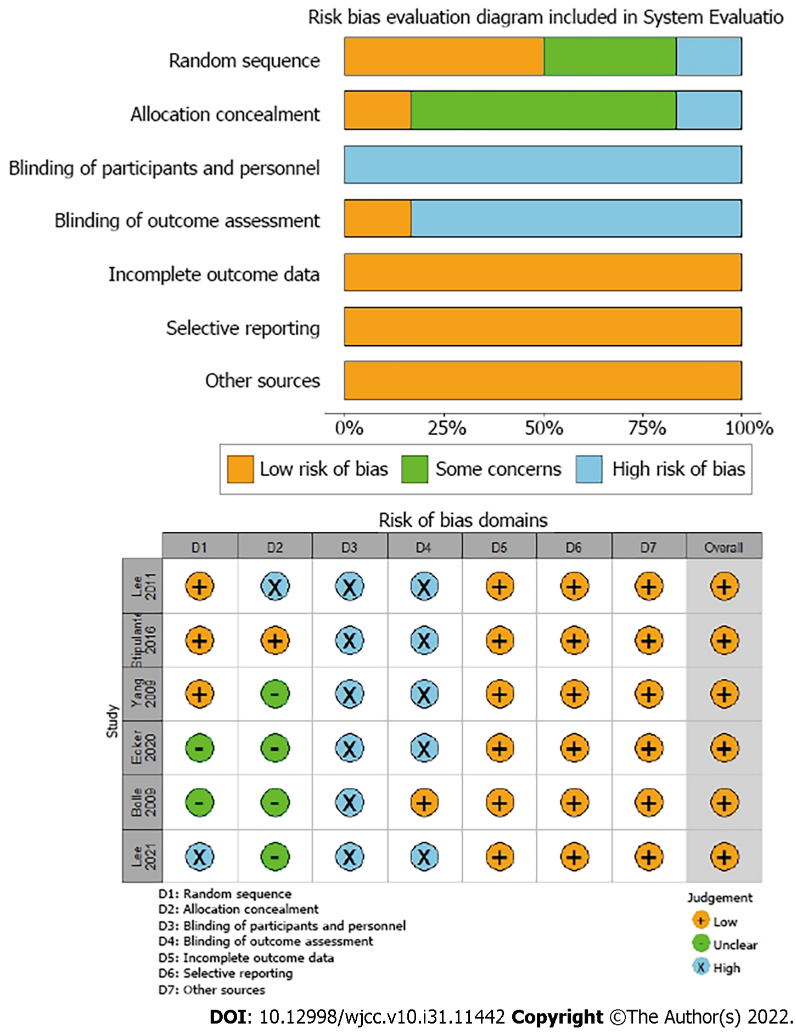

Figure 2 The results of the risk of bias assessment.

"Hands-off" time was reported in four studies[26-29]. However, the statistical heterogeneity was apparent; thus, the qualitative description was used. Two studies[27,29] indicated that volunteers guided by telephone interrupted their chest compression more frequently; and two other studies[26,28] showed a longer hands-off time in V-CPR group due to the poor quality of the signal, and chest

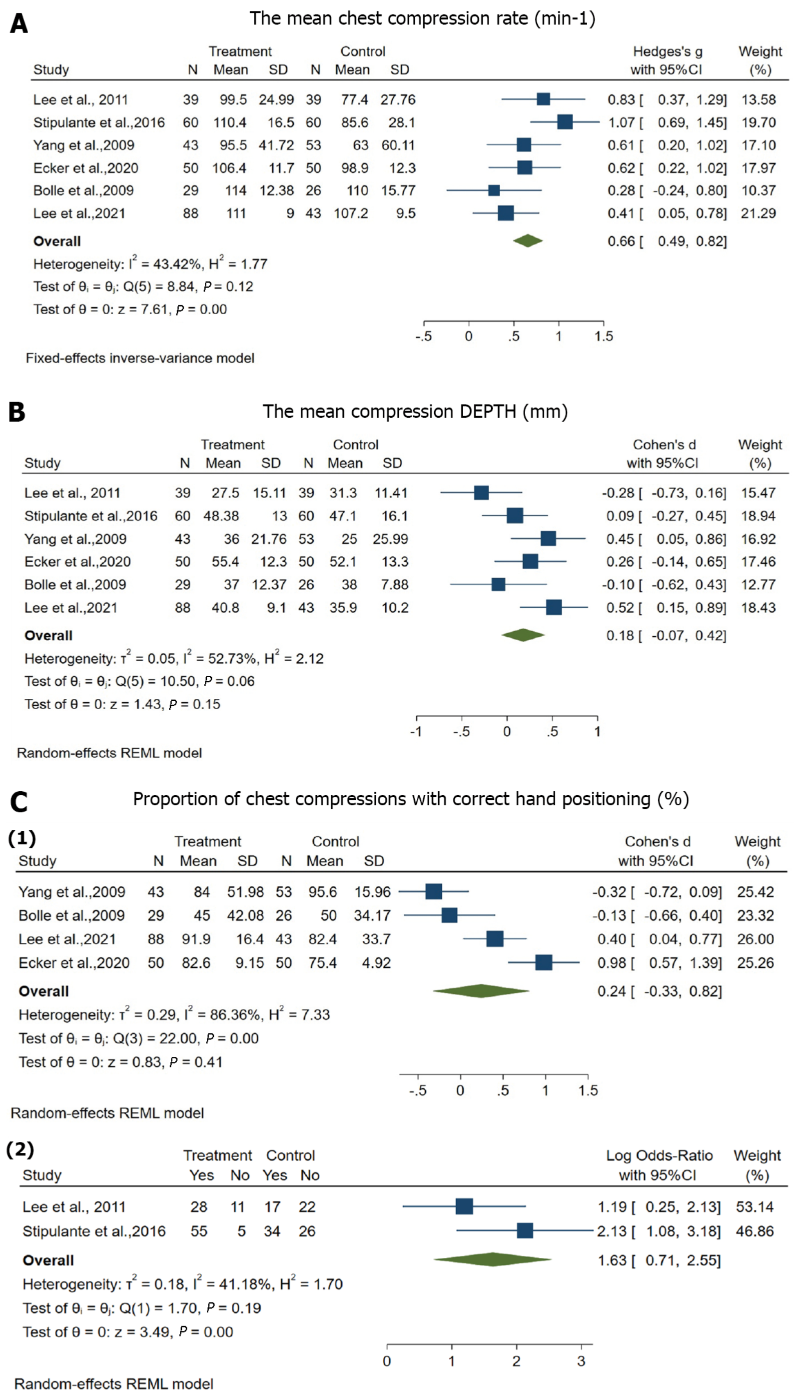

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Figure 3 Forest plot of the quality outcomes of chest compressions.

compression was delayed or broken off.

DISCUSSION

In addition to the instructor and guidance factors, the modes of communication, including telephone voice guidance and remote video online guidance, are important factors affecting the quality of DA-CPR. Video instructions through a telephone can be a potentially powerful tool for CPR instruction in emergencies. Previous studies showed that DA-CPR with video instructions improved rescuers' self-reported confidence, which could positively affect the number of bystanders willing to start CPR[30]. Besides, video-calls influenced the information basis and understanding of the dispatchers, thereby improving the rescuer compliance[17].

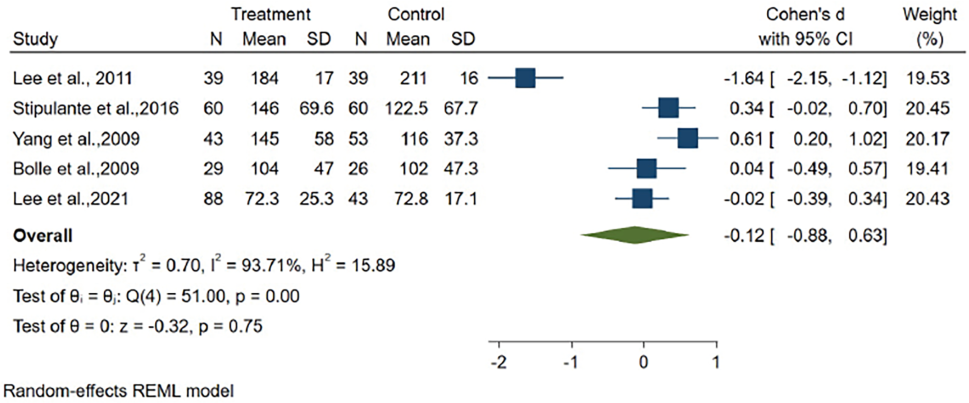

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Figure 4 Forest plot of time to first chest compression.

There is no unified quality evaluation standard for DA-CPR at home and abroad, but in the comprehensive literature[31,32], the overall quality evaluation index recommends the time of dispatcher accepting emergency calls to judge suspected OHCA, time of starting guidance CPR, time of starting chest compression, location of chest compression, frequency and depth, *etc*. The AHA 2015 guidelines recommended high-quality CPR requiring adequate chest compression depth (50-60 mm), adequate chest compression rate (100-120/min), full chest wall recoil, minimal pause in chest compression, correct hand position during compression, and avoidance of hyperventilation[10].

Our systematic review included 6 randomized controlled trials reporting on the quality of DA-CPR under different communication methods. The meta-analysis results showed that video communication could improve the average chest compression rate of bystanders during simulated CAs. The compression speed increased from an average of 92 min^{-1} in the telephone group to more than 100 min^{-1}, reaching the standard compression rate for CPR. Abella *et al*[22] found that a high chest compression rate was significantly related to the initial return of spontaneous circulation. It is expected that the compression speed improved by video communication can be transformed into a better chance of survival in reality. If the chest compressions are guided by a moving video, it will be easier to maintain a proper chest compression rate. However, by judging from the number of subjects who performed an adequate compression rate, there was still a 10%-70% proportion of subjects who did not achieve an adequate compression rate. This reminds us that when guiding bystanders to perform cardiopulmonary resuscitation, we must emphasize that the compression frequency of bystanders reaches 100-120 times/min as recommended by the AHA guidelines.

The depth of chest compression is another key factor in high-quality CPR. Our meta-analysis revealed that video communication did not improve the average chest compression depth of bystanders during simulated CAs. At the same time, most of the compression depths did not meet the 2015 AHA guidelines for high-quality CPR to a depth of at least 5-6 cm in adults. Regardless of T-CPR or V-CPR, it is realized through interactive real-time feedback between dispatchers and subjects. In this study, most CPR performances did not meet the recommended compression depth. Therefore, it is necessary to emphasize the depth of chest compression during interactive counseling, either through video presentations or phone calls.

According to the AHA and European Resuscitation Council guidelines as the correct hand position on the lower half of the sternum[33]. In the included 6 randomized controlled trials, different description methods resulted in divergent results regarding the correct hand position during chest compression. When as a continuous variable, four studies indicated there was no significant difference between the V-CPR and T-CPR groups, but as dichotomous variable, the other two studies showed V-CPR was significantly associated with the included proportion of chest compression with correct hand positioning. In the included studies, the correct hand position of the participants in T-CPR group was only 43.6%, and that of the participants in V-CPR group was only 45%. The possible reason is that the subjects in T-CPR group may call the dispatcher to ask questions, thus, the position of their hands is changed during chest compression. Video-guided CPR should be able to guide the correct hand position more intuitively to improve the correct hand position. However, some volunteers did not correct their hand position according to the instructions provided in the CPR video, which might be attributed to the small screen or location of the mobile phone. Different positions of the video phone may help to monitor and feedback the quality of CPR performed, such as the horizontal positioning, thereby achieving the adequate compression depth; on the other hand, the bird's eye view can optimize the judgment of hand positioning. Nevertheless, further research is needed to determine the best location of the video phone and the information obtained during DA-CPR.

Time to first chest compression is an important time-related quality parameter. In this meta-analysis, the V-CPR group had no significant improvement in time to first chest compression compared to the T-CPR group. In fact, only one study showed that the time to first chest compression was 72 s; while the remaining 5 studies were all greater than 100 s, and the longest record reached 211 s. Such delay can exhibit an impact on the survival rate of patients with CA. These were limited by the low quality of the video connection and poor training of the dispatcher in using video calls. Although the dispatcher gave accurate instructions, the bystanders in T-CPR group lacked a clear understanding and repeatedly asked questions, thus resulting in a time extension.

There were some inevitable limitations to this systematic review and meta-analysis. Firstly, this study incorporated simulation trials with mannequins, while might not represent real-life CAs. In fact, some bystanders can get plagued with fear; thus, more real-life studies with standardized protocols are needed in the future. Secondly, although the 2015 AHA guidelines recommended that dispatchers should provide CPR instructions with only chest compression for adults with suspected OHCA, the emergency medical services are different and there are no unified standardized scheduling tools, hence, the instructions provided by the dispatcher may be varied. Thirdly, the research subjects included both adult volunteers and high school students, which could lead to differences in CPR quality due to their ability to learn from mobile videos. Although adult volunteers (average age = 50 years) reported that they had no difficulty watching and understanding mobile videos, further research should target on older volunteers who are more likely to encounter patients with CA. Fourthly, most included studies did not report the adjusted ORs of primary outcomes, and the ORs calculated by cross-tabs did not consider confounding factors. Therefore, the results of this meta-analysis should be interpreted with caution.

CONCLUSION

This study reveals that the average rate of chest compression during simulated CAs can be improved by video-guided bystander CPR. However, the mean chest compression depth and time-related quality parameters, such as the first chest compression and “hand-off” time, demonstrate no significant improvement in V-CPR group. Video real-time guidance by the dispatcher can improve the quality of the bystander CPR to a certain extent, but the quality is still not ideal, and there is a lack of guidance caused by poor video signal or inadequate interaction.

ARTICLE HIGHLIGHTS

Research background

It remains unclear whether video aids can improve the quality of bystander cardiopulmonary resuscitation (CPR).

Research motivation

To prove whether video aids can improve the quality of bystander CPR.

Research objectives

To summarize simulation-based studies aiming at improving bystander CPR associated with the quality of chest compression and time-related quality parameters.

Research methods

Meta analysis.

Research results

V-CPR was significantly associated with the improved mean chest compression rate, and the proportion of chest compression with correct hand positioning.

Research conclusions

Video real-time guidance by the dispatcher can improve the quality of bystander CPR to a certain extent. However, the quality is still not ideal, and there is a lack of guidance caused by poor video signal or inadequate interaction.

Research perspectives

Real-time video coaching of clinical application dispatchers to improve the quality of bystander CPR.

FOOTNOTES

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