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Simulation and education

The use of dispatcher assistance in improving the quality of cardiopulmonary resuscitation: A randomised controlled trial

Teo Ming Hao Nelson[a], *Wong Wen En Joseph*[a,*], *Peter Chen-Yang Nikhil Daniel*[a], *Kweh Ren Hao Clement*[a], *Ho Ren Yi Jonas*[a], *Koh Jia Hong*[a], *Leong Sieu-Hon Benjamin*[b], *Pang Junxiong*[c], *Hwang Yi-Fu Jeff*[c]

[a] *Yong Loo Lin School of Medicine, National University of Singapore, 1E Kent Ridge Road, NUHS Tower Block Level 11, 119228, Singapore*

[b] *Emergency Medicine Department, National University Hospital, National University Health System, 5 Lower Kent Ridge Road, 119074, Singapore*

[c] *Saw Swee Hock School of Public Health, National University of Singapore, 12 Science Drive 2, #10-01, 117549, Singapore*

Abstract

Aims: The introduction of dispatcher assistance (DA) services has led to increased bystander cardiopulmonary resuscitation (CPR) participation rates. However, the extent to which DA improves CPR quality remains unclear. This study aimed to evaluate the efficacy of DA in improving CPR quality among healthcare professionals and laypersons within a multi-ethnic Southeast Asian population.

Methods: A parallel, randomised controlled, open label trial was performed. Four hundred and twelve participants were recruited via convenience sampling in a public location. In a simulated cardiac-arrest scenario, the participants were randomised to perform CPR with DA over the phone (DA+) or CPR without DA (DA-). The ratio of participant assignment to DA+ and DA- was 1:1. The primary outcomes were CPR compression depth, compression rate, no-flow time, complete release of pressure between compressions, and hand location. The assessment involved CPR manikins and human assessors.

Results: A larger proportion of participants in DA + achieved the correct compression rate (34.3% vs 18.1%, $p < 0.001$). There was no difference in the other primary outcomes.

A subgroup analysis revealed that healthcare professionals in DA+ had a higher proportion of correct hand location compared to those in DA- (82.1% vs. 53.5%, $p < 0.05$). There was no significant difference in CPR quality among laypersons with valid CPR certification regardless of whether they received DA.

Conclusion: DA should be provided to laypersons without valid CPR certification, as well as healthcare professionals. The identification of gaps in the current DA protocol highlights areas where specific changes can be made to improve CPR quality.

Keywords: Dispatcher assistance, Cardiopulmonary resuscitation, Healthcare professionals, CPR certification, Randomized controlled trial

* Corresponding author.
E-mail addresses: josephwong5@hotmail.com (W.E.J. Wong), jeff_yf_hwang@nuhs.edu.sg (Y.-F.J. Hwang).

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Introduction

Out-of-hospital cardiac arrest (OHCA) refers to an abrupt loss of heart function happening outside the hospital. OHCA is common, affecting between 350,200 and 368,200 people in the United States of America yearly. In Singapore, this figure is close to 1800 annually. OHCAs are associated with high mortality and morbidity. Survival and post-survival neurologic recovery after OHCA are greatly affected by pre-hospital emergency care such as the provision of high-quality cardiopulmonary resuscitation (CPR).[1–5]

In Singapore, a Dispatcher-Assisted CPR (DA-CPR) programme was implemented nationwide in 2012. In DA-CPR, rescuers perform CPR under telephone guidance from trained dispatchers. Since its implementation, the bystander CPR provision rate increased from 22% in 2012 to 49% in 2015.[6] However, DA-CPR has not been shown to significantly improve survival rates and functional outcomes in Singapore.[7] This is in contrast to studies in other countries which showed increased survival rates and neurological outcomes with the implementation of DA-CPR.[8] A potential cause of this discrepancy could be due to an increase in bystander CPR provision rates without a corresponding increase in the quality of CPR.

There is a paucity of data on CPR quality in DA-CPR. Spelten et al. showed that DA-CPR improved no-flow time (time without effective compressions) and compression rates but did not improve compression depth, hand location, and complete release.[9] However, these findings may not be applicable to an Asian context due to differing dispatcher protocols and differing rescuer profiles.

Furthermore, previous studies on CPR have identified certain rescuer attributes associated with the provision of high-quality CPR, such as working in a healthcare profession, recent CPR certification, and male gender.[10–12] Information regarding whether DA is beneficial in specific rescuer subgroups is sparse. Identifying who benefits from DA can help to determine who should receive it. DA may also affect CPR quality in a different manner among these subgroups. Knowing how DA alters CPR quality in specific subgroups is important in order to adapt protocols for various subgroups.

Thus, this study aims to evaluate whether DA improves the quality of CPR performed within a Southeast Asian population. We focused on the quality of chest compressions, as assessed by five parameters: compression depth, compression rate, no-flow time, complete release of pressure between compressions, and hand location. As a secondary objective, we aimed to identify which subgroups benefit from the provision of DA and, if they benefit, which parameters of CPR quality improve.

Methods

Ethics

Ethics approval was obtained from the National University of Singapore's institutional review board to conduct a randomised controlled trial (NUS-IRB Reference Code S-18-004). Informed consent was obtained at the point of recruitment. Research participants were offered a food coupon valued at S$2.70 or a mobile phone accessory upon study completion.

Participant recruitment

Participants, including the general public and healthcare workers, between the ages of 21 and 70 years were recruited via convenience sampling from a publicly-accessible location in the National University Hospital, Singapore between 3rd and 7th February 2018. People with physical or communication disabilities precluding CPR performances were excluded from this study. Only English-speaking participants were recruited.

Data collection

After recruitment, a questionnaire was administered to participants by members of the study team. Information on age, gender, height, weight, race, highest education level, occupation, and history of prior CPR training was collected. Healthcare professionals were defined as doctors, nurses, dentists, allied health professionals, medical students, nursing students, dental students, emergency medical technicians, and CPR instructors. Participants – both healthcare professionals and laypersons – were considered to have valid CPR certification if they had received CPR training within the past two years, in accordance to the local Basic Cardiac Life Support accreditation guidelines.[13] All healthcare professionals in Singapore have valid CPR certification, undergoing training/re-training every 2 years to obtain this.

Randomisation

Participants were randomly assigned by a study team member (who was not involved in participant recruitment) into two parallel groups in a 1:1 ratio. Participants were randomised to perform either DA CPR (DA+) or unassisted CPR (DA-). The sequence of randomized assignments to DA+ or DA- was generated beforehand by the same study team member prior to the start of data collection, using variable block randomisation from a computer programme.[14] This sequence was strictly adhered to, and was concealed from the rest of the study team using an encrypted, password protected thumb drive. Once the intervention began, neither participants nor assessors were blinded.

Participants in both groups were introduced to a standardised scenario in which they were the only bystander on scene. Participants in the DA+ group were provided with a mobile phone and received instructions over the phone, via a hands-free speaker, to perform compression-only CPR in accordance to a standardised protocol (Supplementary files, appendix I) used by local emergency medical services. These instructions were provided via healthcare professionals trained by an emergency dispatcher. Participants allocated to the DA- group did not receive any form of assistance and were told to perform CPR to the best of their abilities. The simulation continued for two minutes (excluding instruction time) to allow for the recording of at least four to five cycles of conventional 30:2 chest compressions.

Outcome measurements

Laerdal Resusci Anne® manikins were used to assess the quality of chest compressions. Standardised, internationally recognised CPR outcome measures from the 2015 International Liaison Committee on Resuscitation were used in this study.[15] The parameters assessed included compression depth, compression rate, no-flow time, complete release of pressure between compressions, and correct hand location. The average compression rate was defined as the

number of compressions administered per minute. No-flow time took into account the duration in which no compressions were delivered and excluded the time taken to give the participants instructions. Based on the international guidelines, correct CPR technique requires a compression depth between 5 cm and 6 cm, a compression rate between 100 and 120 per minute, a no-flow time of less than 40% of the total compression time, and a complete release of all chest compressions.[15,16] Overall hand location was considered to be correct if the participant maintained correct hand location for at least 50% of the time.

Additionally, human assessors were used to assess aspects of CPR quality that could not be measured by a CPR manikin. Three independent assessors were employed to reduce observer bias and to ensure the reliability and validity of the visual analysis.[17] The parameters assessed included correct kneeling position, correct rescuer position vertically above victim, hand-over-hand placement, palm contact with manikin's chest, correct angle of compression, locking of elbows, and correct hand location on chest. These parameters were adopted based on the international CPR guidelines on the correct way to perform CPR.[18]

Sample size calculation

A previous study found that no-flow time was 20.8% when DA was provided and 56.9% without DA.[9] Using these figures, a sample size of 25 participants per arm, with 50 in total, was required for a significance level of 5% and a power of 80%.[19] These numbers had to be achieved overall *and* in each subgroup for subgroup analysis to be adequately powered. One of the subgroups selected divided participants based on the possession of valid CPR certification. Previous studies have shown the incidence of valid CPR certification to be 9.6% within the Singaporean population.[20] Thus, to obtain a sample size of 50 participants with valid CPR certification (25 in DA+ and 25 in DA-), an estimated 521 participants had to be recruited. As sufficient participants for each subgroup analysis was recruited with 412 participants, further recruitment of participants was held off.

Statistical analysis

Categorical variables were compared using the chi-squared test. Non-parametric continuous variables were analysed using the Mann–Whitney U test while parametric continuous variables were analysed using the independent t-test. P-values less than 0.05 were taken to be significant. Data analysis was performed using the Statistical Package for Social Sciences (Version 20.0, SPSS Inc., Chicago, USA).

Results

Baseline characteristics

Four hundred and twelve participants were recruited and randomised into two arms: 205 in DA+ and 207 in DA- (Fig. 1). No crossover occurred between the 2 arms. Three participants had a change of mind and declined to participate after enrolment (one in DA+ and two in DA-). In addition, one participant from DA- dropped out after recalling a recent surgery precluding squatting and kneeling. In total, 408 records (204 in each arm) were included for analysis. No participant suffered harm as a result of our study.

There were no significant differences in age, gender, weight, highest education level, and possession of prior valid CPR certification across the two groups (Table 1). There was a minor difference of 2 cm in median height between the two groups. However, this difference was clinically insignificant and was not corrected for. There was a difference in the proportion of healthcare professionals between the two study arms (13.7% vs 21.1%, p = 0.050), with 28 healthcare

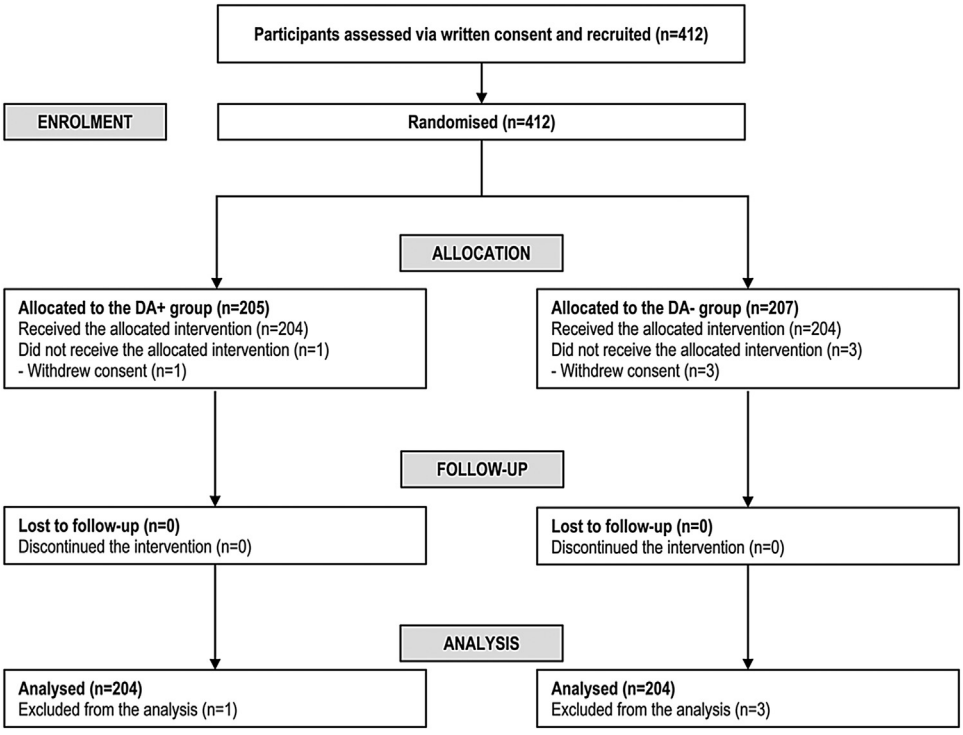

Fig. 1 – CONSORT flow diagram for the study.

Table 1 – Baseline characteristics of the general study population.

	DA+ (n = 204)	DA- (n = 204)	p-Value
Median age (years)	36	33	0.46
Gender			0.11
Male	82 (40.2%)	98 (48.0%)	
Female	122 (59.8%)	106 (52.0%)	
Median weight (kg)	61.0	62.0	0.52
Median height (cm)	163	165	0.03
Education level			0.44
Up to 'O' Level or equivalent	44 (21.6%)	34 (16.7%)	
'A' Level or equivalent	77 (37.7%)	80 (39.2%)	
Degree and above	83 (40.7%)	90 (44.1%)	
Healthcare professionals	28 (13.7%)	43 (21.1%)	0.05
Valid certification	58 (28.4%)	69 (33.8%)	0.24

professionals in DA+ and 43 in DA-. This trended towards significance. As this was a potential confounder in our study, we accounted for it using stratified analysis.

Objective assessment

Overall, participants in DA + performed better only in terms of compression rate. Seventy participants in DA + achieved the correct CPR compression rate of 100–120 per minute compared to 37 participants in DA- (34.3% vs 18.1%, $p < 0.001$) (Table 2). No significant difference was seen in compression depth, no-flow time, complete release between compressions, and hand location.

A stratified analysis was performed based on whether participants were healthcare professionals. Baseline characteristics among non-healthcare professionals were similar, except for height (Supplementary files, appendix II). Non-healthcare professionals had an improvement in compression rate with DA (30.2% vs 13.3%, $p < 0.001$). Among healthcare professionals, only hand location was improved (82.1% vs 53.5%, $p = 0.013$) (Table 3).

Stratification by CPR certification status within non-healthcare professionals showed improved CPR compression rates (32.1% vs 13.1%, $p < 0.001$) in uncertified persons (Table 4). Participants with valid CPR certification did not have any improvement in CPR quality across the five outcomes measured. Stratified analysis by gender was performed within non-healthcare professionals. Compression rate was found to have improved across both genders whereas other factors remained unchanged (Supplementary files, appendix III).

Subjective assessment

With DA, improvements were noted in hand-over-hand placement (94.3% vs 87.0%, $p = 0.020$). However, there was no improvement in correct kneeling posture, rescuer positioning vertically above victim, angle of compression, locking of elbows, and correct hand location. A greater proportion of DA+ participants delivered compressions incorrectly as a larger proportion failed to use the palmar aspect of their hands to deliver chest compressions (84.1% vs 95.0%, $p = 0.001$) (Table 5).

Discussion

To the best of our knowledge, this study is the first randomized control trial to assess the impact of DA on CPR quality in both healthcare professionals and laypersons within a Southeast Asian population. CPR quality is modestly improved when DA is provided. DA improved the rate of chest compression among laypersons and, albeit falling short of statistical significance, among healthcare professionals. Furthermore, among healthcare professionals, the proportion of participants with correct hand location improved with DA. The lack of improvement in the other outcome measures, even with the provision

Table 2 – Results of the general study population.

	DA+ (n = 204)	DA- (n = 204)	p-Value
No. of people achieving the correct depth (%)	32 (15.7%)	46 (22.5%)	0.08
No. of people achieving the correct rate (%)	70 (34.3%)	37 (18.1%)	<0.001
No. of people with NFT ≤ 40% (%)	198 (97.1%)	192 (94.1%)	0.15
No. of people with complete releases (%)	126 (61.8%)	137 (67.2%)	0.26
No. of people with correct hand position more than half the time (%)	103 (50.5%)	100 (49.0%)	0.77

Values = number (percentage of the population); NFT: no-flow time.

Table 3 – Results of the study population stratified by healthcare professional versus non-healthcare professionals.

	Healthcare professionals (n=71)			Non-healthcare professionals (n=337)		
	DA+ (n=28)	DA- (n=43)	p-value	DA+ (n=179)	DA- (n=166)	p-Value
No. of people achieving the correct depth (%)	10 (35.7%)	21 (48.8%)	0.28	22 (12.3%)	25 (15.1%)	0.42
No. of people achieving the correct rate (%)	16 (57.1%)	15 (34.9%)	0.07	54 (30.2%)	22 (13.3%)	<0.001
No. of people with NFT ≤ 40% (%)	28 (100.0%)	43 (100.0%)	–	170 (95.0%)	149 (89.8%)	0.10
No. of people with complete releases (%)	21 (75.0%)	30 (69.8%)	0.63	105 (58.7%)	107 (64.5%)	0.20
No. of people with correct hand position more than half the time (%)	23 (82.1%)	23 (53.5%)	0.01	80 (44.7%)	77 (46.4%)	0.66

Values = number (percentage of the population); NFT: no-flow time.

Table 4 – Results of non-healthcare professionals stratified by valid certification.

	Valid certification (n = 67)			No valid certification (n = 270)		
	DA+ (n = 36)	DA- (n = 31)	p-value	DA+ (n = 140)	DA- (n = 130)	p-Value
No. of people achieving the correct depth (%)	6 (16.7%)	7 (22.6%)	0.54	16 (11.4%)	18 (13.8%)	0.55
No. of people achieving the correct rate (%)	9 (25.0%)	5 (16.1%)	0.37	45 (32.1%)	17 (13.1%)	<0.001
No. of people with NFT ≤ 40% (%)	35 (97.2%)	31 (100.0%)	0.35	135 (96.4%)	118 (90.8%)	0.06
No. of people with complete releases (%)	24 (66.7%)	18 (58.1%)	0.47	81 (57.9%)	89 (68.5%)	0.07
No. of people with correct hand position more than half the time (%)	20 (55.6%)	20 (64.5%)	0.46	60 (42.9%)	57 (43.8%)	0.87

Values = number (percentage of the population); NFT: no-flow time.

Table 5 – Results of the subjective assessment of non-healthcare professionals.

	DA+ (n = 176)	DA- (n = 161)	p-Value
Correct kneeling posture (%)	166 (94.3%)	154 (95.7%)	0.58
Correct rescuer position vertically above victim (%)	158 (89.8%)	143 (88.8%)	0.78
Hand-over-hand placement (%)	166 (94.3%)	140 (87.0%)	0.02
Palm contact with manikin (%)	148 (84.1%)	153 (95.0%)	0.001
Correct angle of compression (%)	110 (62.5%)	104 (64.6%)	0.69
Locked elbows (%)	102 (58.0%)	79 (49.1%)	0.10
Correct hand location on chest (%)	60 (36.6%)	41 (27.7%)	0.22
Too low	73 (44.5%)	80 (54.1%)	
Too lateral	48 (29.3%)	57 (38.5%)	
Too high	2 (1.2%)	5 (3.4%)	
Missing data	12 (7.5%)	13 (8.1%)	

Values = number (percentage of the population).

of DA, may explain why the implementation of DA-CPR was not accompanied by improved survival rates and functional outcomes in Singapore.

In laypersons without valid certification, we attributed the improvement in chest compression rates to the consistent counting provided by the dispatcher — participants achieved the correct rate so long as they followed the rhythm set by the dispatcher. There was, however, no significant change in compression depth, no-flow time, complete release, and correct hand location. More than 75% of the participants failed to compress at an adequate depth regardless of whether DA was provided. The lack of improvement in depth was potentially due to the fear of causing harm as rescuers are often unsure of how deep they can compress without causing harm to the victim.[18] First-time rescuers may also face difficulties estimating the depth required for complete compression.[21] They may therefore decide to compress shallowly out of fear of causing harm by compressing too deeply. A previous study has shown that instructing participants to 'press as hard as possible' rather than telling them to compress to a fixed depth (e.g. 5 cm or 6 cm) is beneficial in improving compression depth in CPR.[22] The lack of improvement in no-flow time was surprising given that participants are guided to push regularly on the manikin with DA. These results suggest that for a duration of CPR up to 2 minutes, laypersons are able to maintain regular chest compressions without assistance. All healthcare professionals, with or without DA, achieved the cut off for no-flow time. This may be due to previous training emphasizing the importance of uninterrupted chest compressions.

The lack of improvement in complete release is likely due to the absence of instructions to allow for complete release during DA. A potential solution would be to include this into the current dispatcher protocol. The lack of improvement in hand location may be attributed to incorrect interpretations of the dispatchers' instructions coupled with poor general knowledge of CPR landmarks. Subjective assessment data showed that despite being told to place their palms on the victim's chest, participants tended to place their hands too low or too lateral. To improve the accuracy of hand placement, instructions could be simplified to 'place your hands exactly between the two nipples', removing the reference to the 'the centre of the chest', which is subjective due to different interpretations of the boundaries of the chest. This suggestion may be helpful to reduce extra sternal compression.[23]

Among healthcare professionals, improvements were noted in correct hand location. This may be because most healthcare professionals had received CPR training as part of their job and DA was a timely reminder regarding correct CPR landmarks. This supports the use of DA even in healthcare professionals.

In participants with valid CPR certification, no significant improvement in CPR quality was found. As all formal CPR courses in Singapore emphasize the importance of compressing at the correct rate, it is possible that this was sufficient to help CPR-trained participants achieve the correct compression rate. However, the small sample size in the subgroup with valid CPR certification precludes a clear conclusion on the effectiveness of DA among them.

With regard to the subjective assessment of the rescuer's body and hand positioning relative to the manikin, hand-over-hand placement was improved with DA. This is likely due to explicit instructions given by the dispatcher to "place one hand on top of the other". However, the percentage of laypersons that correctly provided CPR with palm contact to the manikin decreased with the provision of DA. A number of participants were observed to adjust their hand

position from palm contact to finger contact after hearing the DA instructions to "interlock your fingers". As a result, interlocked fingers were the primary means of providing CPR compression among this group of participants. This suggests that even without instructions, laypersons had a correct understanding that palm contact should be present when performing compressions. DA worsens performance in this aspect, which may be attributable to the misinterpretation of the dispatcher's instructions. Finally, hand location tended to be too low and/or too lateral among all laypersons, regardless of whether they received DA. Thus, an alteration of the DA protocol to address this issue should be considered.

Spelten et al. assessed the CPR quality of laypersons, randomised based on whether they received DA.[9] That study and this current study both found that DA is beneficial in achieving the correct CPR compression rate. This study therefore adds to the evidence that DA should be provided in the general population but also clearly pinpoints the areas where change should be made to improve CPR quality, and identifies healthcare professionals as an additional subgroup that benefits from DA.

Our study had several limitations. Firstly, it was conducted in a single location at a hospital's common area. This may result in an over-representation of healthcare professionals and reduce the external validity of the findings. A subgroup analysis was therefore performed to assess the use of DA in non-healthcare professionals. Secondly, the use of convenience sampling may limit the external validity of the study as recruited participants may be more interested and competent in performing CPR compared to the general public. Thirdly, only 79.9% of the Singaporean population is literate in English.[24] Thus, the exclusion of non-English-speaking adults may have resulted in selection bias in a multi-ethnic community. This was done because the official DA protocol was only available in English, and because local emergency dispatchers initiate calls in English. Fourthly, the duration of CPR participants were asked to perform was 2 minutes. In Singapore, the median ambulance response time is 7.5 minutes.[25] It remains to be seen if DA-CPR will provide benefits in OHCAs requiring longer resuscitation time. A shortened duration of CPR performance was chosen to lower barriers to research participation so as to obtain a better participant response rate.

The strength of our study was that CPR outcomes were assessed using CPR manikins as well as human assessors. This allowed for an identification of not only whether CPR quality was poor but also why it was poor, thus allowing for targeted improvements to the dispatcher protocol.

Conclusion

DA should be provided to both untrained rescuers as well as healthcare professionals. The provision of DA results in an improvement in compression rate among untrained laypersons. In addition, an improvement in hand positioning was observed for healthcare professionals. The identified gaps in the current DA protocol represent areas where targeted changes can be made to improve CPR quality.

Conflict of interest and authorship conformation form

All authors have participated in (a) conception and design, or analysis and interpretation of the data; (b) drafting the article or revising it critically for important intellectual content; and (c) approval of the final version.

The authors have no affiliation with any organization with a direct or indirect financial interest in the subject matter discussed in the manuscript

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Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.resuscitation.2019.03.003.

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