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Improving the position of resuscitation team leader with simulation (IMPORTS); a pilot cross-sectional randomized intervention study

Ismail M. Saiboon, M Surg(Orth&Trauma)[a,*], Farah N. Apoo, MEmMed[a], Shamsuriani M. Jamal, MEmMed[a], Afliza A. Bakar, Arab Board EmMed[a], Fadzlon M. Yatim, MMed[a], Johar M. Jaafar, M Surg(Orth&Trauma)[a], Benjamin W. Berg, MD[b]

Abstract

Background: Leadership and teamwork are important contributory factors in determining cardiac resuscitation performance and clinical outcome. We aimed to determine whether fixed positioning of the resuscitation team leader (RTL) relative to the patient influences leadership qualities during cardiac resuscitation using simulation.

Methods: A cross-sectional randomized intervention study over 12 months' duration was conducted in university hospital simulation lab. ACLS-certified medical doctors were assigned to run 2 standardized simulated resuscitation code as RTL from a head-end position (HEP) and leg-end position (LEP). They were evaluated on leadership qualities including situational attentiveness (SA), errors detection (ED), and decision making (DM) using a standardized validated resuscitation-code-checklist (RCC). Performance was assessed live by 2 independent raters and was simultaneously recorded. RTL self-perceived performance was compared to measured performance.

Results: Thirty-four participants completed the study. Mean marks for SA were 3.74 (SD ± 0.96) at HEP and 3.54 (SD ± 0.92) at LEP, $P = .48$. Mean marks for ED were 2.43 (SD ± 1.24) at HEP and 2.21 (SD ± 1.14) at LEP, $P = .40$. Mean marks for DM were 4.53 (SD ± 0.98) at HEP and 4.47 (SD ± 0.73) at LEP, $P = .70$. The mean total marks were 10.69 (SD ± 1.82) versus 10.22 (SD ± 1.93) at HEP and LEP respectively, $P = .29$ which shows no significance difference in all parameters. Twenty-four participants (71%) preferred LEP for the following reasons, better visualization (75% of participants); more room for movement (12.5% of participants); and better communication (12.5% of participants). RTL's perceived performance did not correlate with actual performance

Conclusion: The physical position either HEP or LEP appears to have no influence on performance of RTL in simulated cardiac resuscitation. RTL should be aware of the advantages and limitations of each position.

Abbreviations: ACLS = advance cardiovascular life-support, AHA = American Heart Association, CPR = cardiopulmonary resuscitation, DM = decision making, ED = error detection, HEP = head-end-position, LEP = leg end position, PALS = pediatric advance life support, Q-CPR = quality cardiopulmonary resuscitation, RCC = resuscitation code checklist, RTL = resuscitation team leader, SA = situation attentiveness, TCF = training center faculty.

Keywords: advanced, cardiac life support, cardiopulmonary resuscitation, leadership, patient simulation

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The authors report no conflicts of interest.

[a] Faculty of Medicine, Universiti Kebangsaan Malaysia, Cheras, Kuala Lumpur, Malaysia., [b] SimTiki Simulation Center, John A Burns Medical School, University of Hawaii at Manoa, Honolulu, HI, USA.

[*] Correspondence: Ismail M. Saiboon, Department of Emergency Medicine, Faculty of Medicine, Hospital Canselor Tuanku Muhriz, Jalan Yaakob Latiff, Bandar Tun Razak, Cheras, 56000 Kuala Lumpur, Malaysia (e-mail: fadzmail69@yahoo.com.myismail@ppukm.ukm.edu.my)

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1. Introduction

Advanced cardiovascular life support (ACLS) courses mainly focus on technical knowledge and skills. However, non-technical skills like leadership and teamwork have recently been accepted as important contributory factors in determining cardiac resuscitation performance and clinical outcomes.[1,2] There is growing evidence that poor leadership behavior and deficient teamwork lead to poor Cardiopulmonary Resuscitation (CPR) quality and adverse outcomes.[3,4,5] The 2010 American Heart Association (AHA) course guidelines incorporate an expanded recommendation to integrate leadership training within the ACLS and pediatrics advanced life support (PALS) provider courses.[6,7] Several observational clinical studies investigating the importance of leadership during cardiac resuscitation have been published. Amongst the earliest studies was a 1999 observational study by Cooper[8] which found that team leaders who did not participate in the "hands on" clinical skills but instead focused on building a structure within the team and managing the team had better team dynamics and task performance outcomes. Similar findings were noted in observational studies in pediatric resuscitation.[9,10] The presence of specialist senior pediatric physicians enhanced both team collaboration and technical performance[9] while deficient leadership and communication breakdowns contributed significantly to perinatal deaths and injuries.[10] In a study by Hoff et al, review of trauma resuscitation video tapes concluded that explicit identification of a command-physician or team leader is identified, trauma resuscitation performance is enhanced with a resuscitation process which is more structured and that adherence to algorithms is improved.[11] Improved clinical and simulation-based resuscitation outcomes correlate with the presence of strong leadership skills.[12,13,14]

Due to the fast pace during heterogenous and dynamic clinical scenarios, assessment of leadership skills during 'real-life' cardiac resuscitation is challenging. Recent emergence of simulation training in cardiac resuscitation provides an opportunity for a more standardized approach which can fill gaps left behind by real-life studies. Resuscitation research using simulation as an investigative methodology has the advantage of providing a controlled environment in which multiple interventions can be systematically applied and studied. Advancement of technology allows for standardized and repeated replication of multiple clinical situations in a realistic environment. Video-recording of simulation sessions enables a more detailed and rigorous analysis of leadership behaviors, team interactions, and resuscitation performance.

Several factors influence team performance including verbal and non-verbal communication, situational attentiveness, leader ability to make quick and correct decisions, assigning team roles etc. We sought to explore whether the physical position of the team leader in relation to the patient during resuscitation impacts overall team resuscitation performance. The position of a team leader within a fast-paced and noisy resuscitation environment is likely to affect his or her situational attentiveness, error detection (ED), decision making (DM), and communication with the other team members. We believe that optimal position of a team leader and other team members is one of the least explored areas in cardiac resuscitation teamwork. An optimal position will allow the team leader to gather adequate information with a comprehensive view of the patient, team members, and physiologic display monitors.[15] International and regional guidelines inconsistently recommend a variety of different physical positions for the team leader. The AHA recommends that the team leader is positioned at the patient's left side at the level of the lower limbs, in a 6 person team.[6] A hospital guideline by Prince et al in 2014[16] stationed the team leader at the patient's right side at the groin level while another guideline by Cabanas et al in 2015[17] for regional emergency medical services positioned the team leader at the head of the patient adjacent to airway management personnel.

Few studies have compared different positions for CPR providers and assessors during resuscitation. A study by Jones et al in 2015[18] assessed the optimal position for accurate visual assessment of CPR quality in pediatric resuscitation. A hundred twenty-five participants viewed video recordings of both high quality and poorly performed CPR filmed from 3 different positions; the head, side and foot of the manikin. Positioning at the side of the bed was found to be superior than the other positions for accurate assessment of CPR quality. Additional studies assessed the best position for CPR providers to deliver high quality chest compression.[19,20,21] Across the board, there are varying recommendations and practices regarding team leader positioning during cardiac resuscitation. Literature review fails to support evidence-based superiority of any specific team leader position. The paucity of information regarding effects of team leader positioning on leader performance or overall team performance could be attributed to the complexity and difficulty conducting leader positioning research in real-life clinical situations. Therefore, we employed simulation-based teamwork exercises as method to study this topic. In order to compare outcomes related to team leader position during cardiac resuscitation, we carried out a cross-sectional randomized intervention study to compare the impact of team leader position on 3 primary leadership performance outcomes during simulated cardiac resuscitation according to their positions.

(1) situational attentiveness (SA),
(2) ED, and
(3) DM

In this study we hypothesized that the leg-end position (LEP) was the most effective position for resuscitation team leader (RTL).

2. Methods

We conducted a cross-sectional randomized intervention study between 1st May 2016 and 30th April 2017, involving ACLS certified healthcare professionals. The study was conducted at the simulation lab Department of Emergency Medicine, Universiti Kebangsaan Malaysia Medical Centre (UKMMC), and was approved by the research and ethical committee of Universiti Kebangsaan Malaysia (JEP-2016-010) and funded by an Action Research Grant from UKM (UKM-PTS-2014-088).

We performed an English language literature search using PubMed, Ovid, Science Direct, and The Cochrane Library to identify studies which assessed the impact of varying the position of the team leader on team performance during cardiac resuscitation. The search words used were "team leader", "resuscitation", "position", and "performance". This search failed to yield any study which explicitly explored resuscitation performance, teamwork, or leadership outcomes of various RTL positioning.

A convenience sample of ACLS certified physicians in our institution was recruited for this study. Those who refused to be video-taped or give consent were excluded. Inclusion criteria included completion of an ACLS-provider or ACLS-provider renewal course within 2 years before enrolment.

2.1. Study tools

Two resuscitation scenarios were developed by the researchers (IMS, FNA, and MJJ) based-on the AHA's ACLS megacodes scenarios. Trained confederates were utilized for non-leader scenario team roles. A resuscitation-code-checklist (RCC) was developed based on a modified Delphi-like process including serial RCC version review, modifications, discussion, and final consensus of an expert panel (SMJ, AAB, and FMY) and the researchers (IMS, FNA). A 2-stage study questionnaire queried participant demographics, performance self-perception, and positioning preference.

2.1.1. Resuscitation scenarios. Two standard resuscitation scenarios were developed. Each scenario contained 4 sequential arrhythmia based dynamic clinical conditions. Progression of the key elements of the resuscitation "code" scenarios follows;

Scenario 1: Unstable tachycardia → ventricular fibrillation → pulseless electrical activity → return of spontaneous circulation
Scenario 2: Unstable bradycardia → asystole → ventricular fibrillation → return of spontaneous circulation

Each scenario design incorporated specific pre-planned situational changes and errors, with defined critical events requiring observable DM and interventions by the team leader in accordance with ACLS protocols.

2.1.2. Resuscitation code checklist (RCC). The RCC was divided into 3 assessment sections; SA, ED, and DM. A maximum score of 17 comprised of 5 points for SA, and 6 points each for ED and DM. The RCC was a content-validated tool developed by the ACLS training center faculty (TCF), ACLS instructors, emergency physicians, medical educators and study researchers at our institution.

In order to minimize inter-rater variability, raters underwent a standardized rater-calibration process. Six raters were recruited among certified AHA ACLS instructors. They were briefed about the study. Rater training calibration included scoring of a live simulated cardiac resuscitation according to a pre-designed checklist (RCC). Rater scores were then compared to pre-established "gold-standard" scoring. Scoring deviation within ± 2 points of the total score was acceptable. When the difference in score was more than ± 2 points, raters scored a repeat live resuscitation code until the difference in rater scoring came within ± 2 points from the standard.

2.2. Video recording

Each resuscitation scenario "code" was recorded in its entirety using a standardized digital audio-video recorder. Recordings were reviewed and used for scoring only when required to clarify areas or actions of ambiguity.

2.2.1. Questionnaire. A questionnaire was completed in 2 stages by all participants. The questionnaire was reviewed for face and content validity by qualified ACLS instructors. Pre-scenario items included demographics, time lapse since the last ACLS certification course, and personal resuscitation experience. Post-scenario items included participant global rating of their own performance on a scale of 1 to 10 (1 = very dissatisfied and 10 = very satisfied), preferred team leader positioning, and narrative reasoning behind their preference.

2.2.2. Confederates. For each simulation code scenario, 4 team members were selected from a pool of 8 confederates who underwent standardized training and pre-scenario briefing. A team of 8 healthcare professionals (medical assistants, staff nurses, and physicians) were recruited and trained as standardized scenario ACLS team member confederates. Confederate roles included one person providing chest compression, 1 person managing airway, 1 person managing the defibrillator and defibrillation, and 1 person preparing and administering intravenous (IV) medications and fluids. They underwent training to complete role familiarization and to standardize performance. A written performance template was provided to maintain standardization and reproducibility of each session.

2.3. Study protocol

Eligible participants were invited to enroll for the study. Those who did not fulfill the inclusion criteria were excluded. We created 2 standard simulation scenarios (megacodes) on cardiac resuscitation that were replicated throughout the study (Study Tool 1). On the day of study before completing the megacode scenarios enrolled participants provided written consent, completed the pre-scenario questionnaire items, and were briefed regarding the study purpose and their roles. Standardized briefing elements included team leader role and responsibilities, confederate roles and responsibilities, simulator orientation, and orientation to the resuscitation room including equipment and supplies. Participants need to complete 2 sequential scenarios, with a 5-minute break interval between scenarios. Debriefing was not conducted.

The first scenario as team leader was assigned, to start in either head-end position (HEP) or leg-end position (LEP), via sealed envelope block randomization by the primary researcher. The second scenario was completed with the team leader starting in the alternate position. Simulated resuscitation was limited to 10 minutes as determined by the simulation technician who recorded scenario duration, or terminated when all pre-identified key clinical actions had been completed.

Upon assignment to a starting position each participant assumed the role of a RTL. He or she was assisted in scenario case management by a team of four confederates. Confederates played assigned roles, that is, managing airway, drugs and fluid management, chest compression and defibrillation. Throughout the code scenario, participants were permitted to re-position within the allocated area as desired, to best resemble natural behavior in a real-life resuscitation code. Participants or team leaders were not allowed to move beyond their allocated positions at any time during the code.

Each resuscitation code scenario was assessed live by 2 assessors. Every session was video-taped for a more in-depth assessment as required. Participants were not permitted to pause the code scenario at any time. After participants completed the sequential code scenarios at both positions, they completed the post-scenario questionnaire (Study Tool 4) which evaluated the participant preferred position.

Environmental fidelity standardization was verified before each scenario, including positioning of equipment and supplies in the single emergency department resuscitation bay utilized for this study (Fig. 1). Two high-fidelity adult manikin (Laerdal SimMan Mark 2, Starvanger, Norway) were used in each scenario.

2.4. Statistical methods

There is no published fixed effect size to guide sample size calculation. A priori estimate of the meaningful range between LEP and HEP scores on the validated performance parameters was determined by consensus of our institutional AHA ACLS instructors and medical educators experienced in simulation training. A 3-point difference in mean score, with $\pm$SD of ± 4 was used to calculate a sample size estimate of 37 for each of the 2 positions.[22]

Quantitative and quasi-qualitative data descriptive statistics were analyzed using Microsoft Excel 2015 edition and IBM SPSS Statistics v23.0.

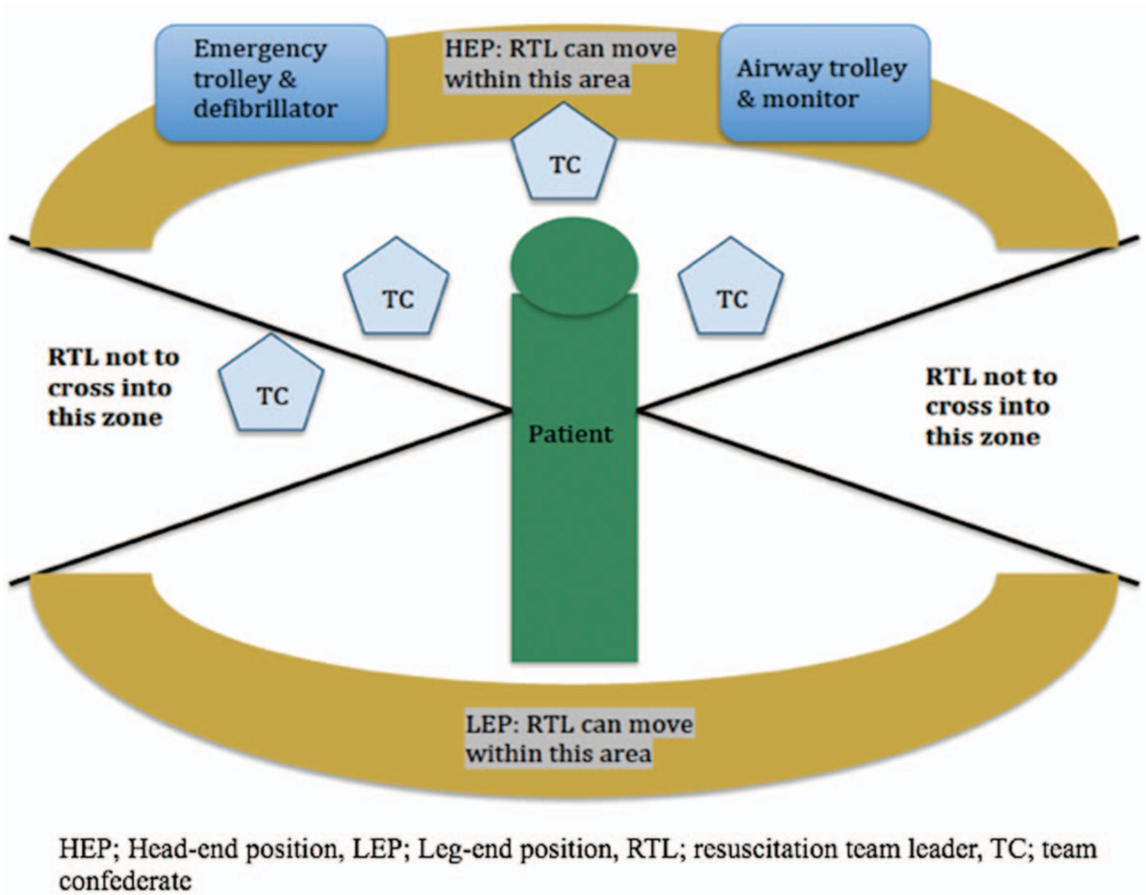

Figure 1. Resuscitation room configuration. Showing the area of RTL in HEP and in LEP, 'patient' location, confederates, defibrillator, airway trolley, and patient monitor.

HEP and LEP mean total RCC score differences did not approximate a normal distribution. Wilcoxon signed-rank test for 2 related samples was used to assess differences in the population mean ranks, and for the difference in scores in the 3 assessment domains; SA, ED, and DM. The null hypothesis was that there is no difference in the two measurements. The critical z value of 95% confidence interval was used.

Intra-class correlation coefficient (ICC) estimates and 95% confidence intervals were calculated using SPSS statistical package ver. 23 based on absolute agreement, 2-way mixed-effects model.

3. Results

Thirty-four ACLS certified physicians completed this study, comprising a total of 68 rated scenarios. (Fig. 2). Rating was completed by 2 observers for each session, comprising a total of 136 total ratings. Each of 6 raters rated an average of 23 scenarios (range 4–34). Intra-class correlation coefficient values for total RCC score at HEP and LEP were 0.841 and 0.779, respectively, indicating good inter-rater reliability. Majority of the participants were female between the ages of 30 to 35 years old. Their status of post-graduate training, ACLS certification and time lapse since last ACLS were documented (Table 1).

Resuscitation leadership was rated in three domains using the RCC assessment tool; SA, ED; and DM. All domains were assessed during each of the 2 simulation resuscitation completed by participants. SA mean RCC score was 3.74 (SD $\pm$ 0.96) for HEP, 3.54 (SD $\pm$ 0.92) for LEP; $P=.483$. ED mean RCC score was 2.43 (SD $\pm$ 1.24) for HEP, 2.21 (SD $\pm$ 1.14) for LEP; $P=.403$. DM mean score was 4.53 (SD $\pm$ 0.98) at HEP, 4.47 (SD $\pm$ 0.73) for LEP; $P=.704$. RCC total score mean was 10.69 (SD $\pm$ 1.82) for HEP and 10.22 (SD $\pm$ 1.93) at LEP; ($P=.291$).

Total scores range was 7 for HEP and 8 for LEP, the interquartile range for three domains is shown in (Fig. 3). HEP and LEP interquartile rages were 2.38 and 2, respectively. Median total RCC score for HEP was higher (10.75) than LEP (10.25). HEP RCC scores approximated a bell shape distribution, but LEP values were negatively skewed to the left (Fig. 4). Wilcoxon signed rank test for 2 related samples did not reveal a difference in total scores between the 2 groups ($Z=-1.012$, $P=.311$).

Analysis of participant response time to situational changes and errors was categorized as $\leq$5 seconds, $>$5 seconds, or not detected (Table 2). There was no statistically significant difference in speed of detection between both positions across all parameters. The number of subjects who did not detect standardized embedded scenario probes for situational changes or ED was near equal in both groups. Several parameters were consistently not detected by the team leader, regardless of position; for examples, mask malposition and asynchronous ventilation.

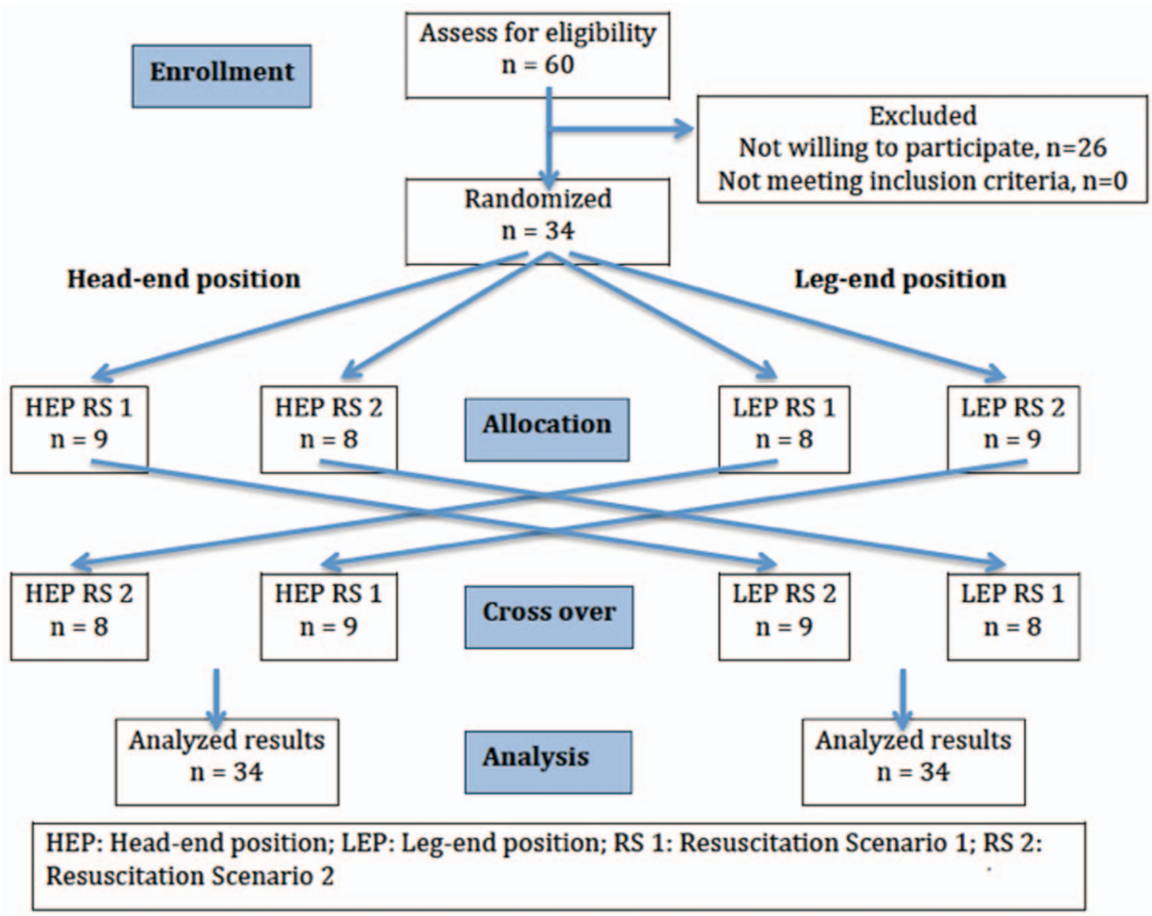

Figure 2. Participants' distribution according to study flow.

Table 1

Participant demographics.

Characteristics	n (%)
Gender	
Male	10 (29.4%)
Female	24 (70.6%)
Age	
25–30 yr	2 (5.9%)
31–35 yr	30 (88.2%)
36–40 yr	2 (5.9%)
Year of post-graduate training	
Year 1	1 (3%)
Year 2	5 (14.7%)
Year 3	16 (47%)
Year 4	12 (35.3%)
ACLS certification	
AHA	23 (67.6%)
Non-AHA (ILCOR)*	11 (32.4%)
Time elapsed since last ACLS course†	
Less than 6 months	14 (41.2%)
More than 6 months	20 (58.8%)

* ILCOR 2010 Guidelines
† All participants had their ACLS provider course within the previous 2 yr when they enrolled in this study

Twenty-four (70.6%) of subjects indicated a preference for LEP, the remainder preferred HEP. Reasons for choosing LEP included better visualization of surroundings, more room to move around, and perceived better communication with team confederates. HEP was preferred because it allowed team leaders to be closer to patient while performing history taking, improved ability to perform assessment, and positioning closer to monitors, equipment and team confederates.

Self-perception of performance range was 3 to 9, on a 10-point scale. The majority of participants (15 out of 34) gave an average score of 5. Perceived performance score was correlated with actual total score using the Spearman rank order correlation. There was a very weak positive correlation between self-perceived score and actual score, which was statistically not significant. (Rs (34): +0.163 $P = .5$). Hence, there is no correlation between participants' perceived performance and actual score. Participants did not consistently score higher marks at their preferred position. Of the 24 participants who preferred LEP, only 10 participants scored higher at this position. Of the 10 participants who expressed preference for HEP, only 6 had better scores at this position.

4. Discussion

We found that the team leader position at either head or leg during a simulated cardiac resuscitation scenario had no

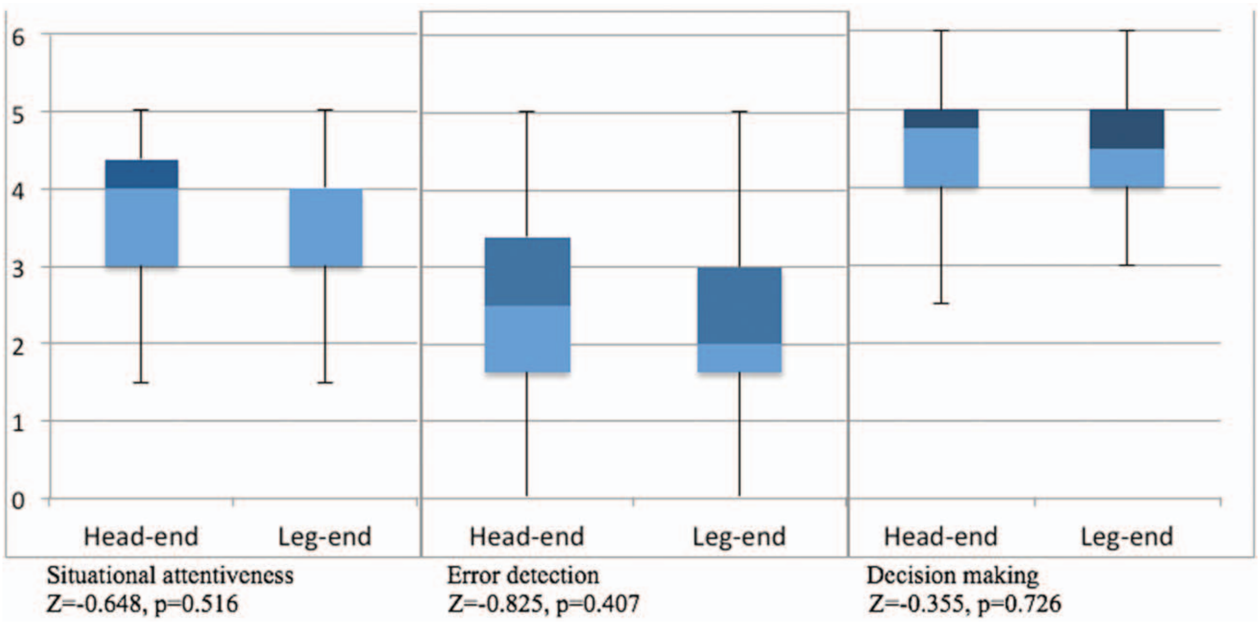

Figure 3. Box plots and *P* values (using Wilcoxon signed rank test) for situational attentiveness, error detection and decision making according to position.

detectable influence on the team leader's performance, although there was a trend to better performance at HEP. The mean difference in performance score was not statistically significant for the three domains we assessed; situational attentiveness, ED, and DM. Our results were unexpected, considering that LEP is advocated in 2010[6] and 2015 AHA ACLS guidelines.[23] Our findings challenge this widely implemented practice for both training and patient care settings. Although, there was no statistically significant difference in team leader scores in the 2 positions, there was a consistent trend toward better team leader's performance at HEP in all three domains.

Scores did not follow a normal distribution. For both positions, the majority of scores were between 9.5 (56% maximal possible) and 11.5(68% maximal possible) with very few outliers at either end. These scores of 56% to 68% of maximal possible performance serve as indicator of ACLS certified physicians' performance level at our center. SA, ED, and DM were chosen as parameters for team leaders' performance because they represent important and quantifiable indicators. Communication is a key RTL skill, which was not assessed in this study.

The difference in HEP and LEP scores for both SA and ED were slightly higher compared to DM. The difference in marks between HEP and LEP for SA and ED were 0.2 marks or 3.3% and 0.22 marks or 4.4%, respectively, whilst the difference in marks for DM was only 0.06 marks or 1.0%. This suggests that RTL's position might exert a greater influence on the

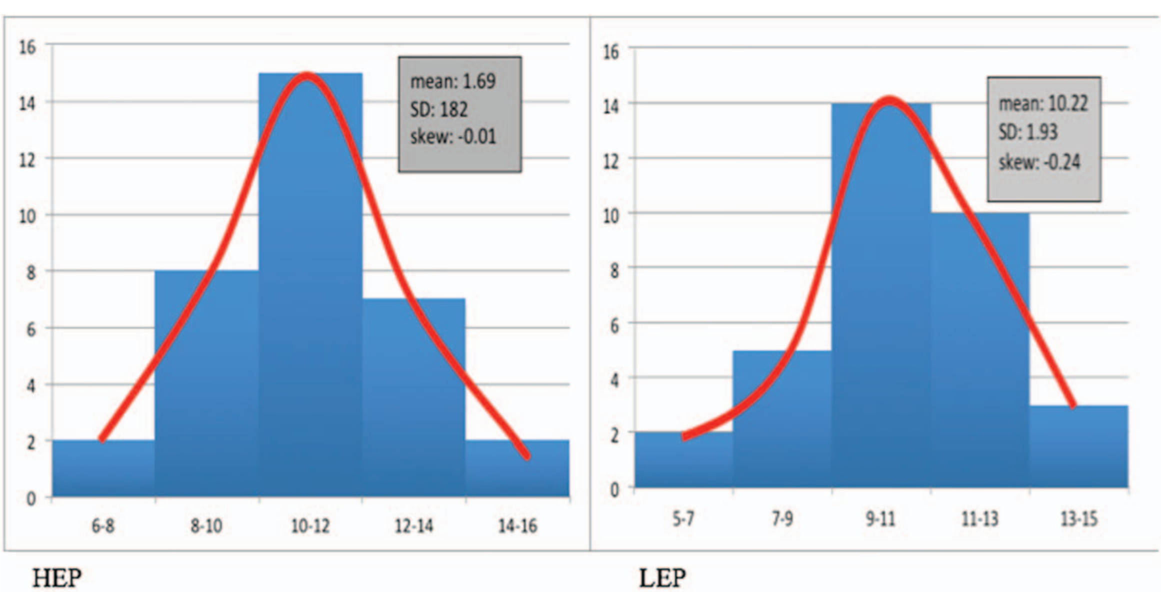

Figure 4. Histogram for mean total marks at head-end-position and leg-end position.

Table 2

Detection of clinical transitions and errors according to position and associated *P* values.

Clinical events		<5 s	>5 s	Not detected	*P* value
		N (%)			
Situational attentiveness					
Drop in BP	HEP	20 (58.8)	8 (23.5)	6 (17.7)	
	LEP	15 (44.1)	16 (47.1)	3 (8.8)	0.111
Apnoea	HEP	16 (47.1)	5 14.7)	13 38.2)	
	LEP	10 (29.4)	10 (29.4)	14 (41.2)	0.213
Rhythm change #1	HEP	27 (79.4)	6 (17.7)	1 (2.9)	
	LEP	28 (82.3)	6 (17.7)	-	0.601
Rhythm change # 2	HEP	29 (85.3)	3 (8.8)	2 (5.9)	
	LEP	25 (73.5)	6 (17.7)	3 (8.8)	0.473
Resumption of Breathing	HEP	15 (44.1)	9 (26.5)	10 (29.4)	
	LEP	9 (26.5)	12 (35.3)	13 (38.2)	0.313
Error detection					
Mask malposition	HEP	3 (8.8)	6 (17.6)	25 (73.6)	
	LEP	1 (2.9)	7 (20.6)	26 (76.5)	0.577
Inadequate compression depth	HEP	14 (41.2)	4 (11.8)	16 (47.0)	0.673
	LEP	11 ‘(32.3)	6 (17.7)	17 (50.0)	
Asynchronous ventilation	HEP	5 (14.7)	4 (11.8)	25 (73.5)	
	LEP	3 (8.8)	5 (14.7)	26 (76.5)	0.729
Slow compression rate	HEP	13 (38.2)	7 (20.6)	14 (41.2)	
	LEP	13 (38.2)	11 (32.4)	10 (29.4)	0.459

observational-response aspects (parameters assessed in SA and ED) as opposed to cognitive-based aspects (parameters under DM). A sub-analysis of situational attentiveness parameters indicated that HEP team leaders were better able to detect breathing changes than LEP leaders, without influencing detection of changes that were displayed on monitors.

Increasing amounts of external input or distractions are known to have detrimental effects on visual registration, processing, and other cognitive tasks.[24] Mastroberardino and Vredeveldt demonstrated that general attention resources are diminished when individuals attempt to block out unwanted stimulation, leaving less of a limited cognitive capacity for attention to primary tasks.[25] This construct applies to team leaders at LEP in our study, wherein their forward gaze incorporates the entire resuscitation context, compared to a more limited HEP visual perspective. LEP leaders encountered more visual stimuli to register and process, including team member activities, direct vision of the patient, and physiologic display monitors. HEP leader forward gaze on the other hand incorporated a more limited number of contextual elements, since it was directed towards the patient and team members, and did not incorporate monitors. Monitor viewing required active turning of the primary gaze axis by approximately 180 degrees to observe monitors, when information acquisition was deemed necessary, or at 2-minute rhythm check intervals. Six out of 12 DM items scored for tachycardia and bradycardia algorithms assessed participant knowledge alone; the remainder of DM scored items reflected decisions made in response to participant SA and ED. This equal balance of knowledge and teamwork DM scored elements may account for the minimal difference between HEP and LEP DM scores, despite a difference in the amount of visual information confronting leaders in each position.

Participant speed in detecting errors and situational changes were similar for both positions, except for detection of cessation and initiation of patient spontaneous breathing. In SA, both positions showed better detection of a monitor-displayed rhythm change, compared to patient-based assessment of cessation or initiation of spontaneous breathing. The non-detected rate was ≥30% in patient-based changes. In ED, the non-detected error rate was greater for ventilation mask malpositioning and asynchronous ventilation-compression.

Previous resuscitation observational studies evaluated a specific skill or a set of related participant skill (s) for either individual team members (eg, team leader, or other roles), or for members of the team as a group. Visual awareness of CPR quality is a skill that has been assessed in multiple studies.[26,27] Teamwork and leadership non-technical skills during resuscitation are likewise well studied.[13,28,29] The influence of team leader physical position on resuscitation performance has been less well investigated. A study by Jones et al assessed the best position for optimal visual accuracy of CPR quality[18] and Hargestam studied non-verbal communication in a simulated trauma resuscitation.[30]

Four elements of our study uniquely present methods and data, not previously investigated. First, we attempted to assess multiple skill sets of a team leader, that is, situational attentiveness, ED and DM, in a controlled environment with multiple standardized assessment points. Assessments were designed to individually and, in the aggregate, broadly reflect overall performance, and were not restricted or compartmentalized to any single skill. This contrasts with other published studies incorporating positioning, such as Jones et al which that only assessed visual assessment of CPR skill.[18]

Second, given the paucity of literature that explicitly explores this issue our study evaluated and provided insight regarding the influence of a team leader's physical position on resuscitation performance. We explored the position of team leader at the HEP and LEP in cardiac resuscitation, in contrast to Hargestam et al who compared the position of team leaders in trauma resuscitation by categorizing "inner circle" and "outer circle" positioning.[30] Her study examined non-verbal communication skills amongst team leaders in simulated trauma resuscitation, and found better performance amongst participants who positioned themselves within the inner circle. It is the norm that the team leaders' chosen position is based on their familiarity and preference alone but as reflected in this study, team leaders' chosen position did not translate into better performance. It is our hope that this study provokes ACLS instructors and providers to think critically about team leader physical positioning during cardiac resuscitation, and to be consciously aware of advantages and disadvantages of various positioning options. Furthermore, this study provides several practical steps which may inform future efforts to mitigate disadvantages of various team leader positioning. For example, resuscitation room design may be improved through use of larger monitor screens to allow for better visualization when team leaders are at the leg-end position. Alternatively, multiple monitors such as an additional monitor adjacent to the leg-end position may address the issue of line of site obstructions for team leaders and other team members. Additionally, creation of more space at the head-end position to allow for greater mobility will create an ergonomically more conducive RTL position.

Thirdly, the study incorporated real-time assessment as opposed to performance assessment of video recorded resuscitation, recreating a realistic environment that more resembles actual cardiac resuscitations. Our scripted scenarios presented numerous standardized distractors simulating real cardiac resuscitation and exposed leaders to general unscripted distractions, such as team member movement and general ambient noise. Furthermore, this study was able to critically evaluate and demonstrate advantages and disadvantages associated with two different team leader position during simulated cardiac resuscitation scenarios. We discovered that a visually expansive bird's eye view of the resuscitation environment, monitors, and team members at the LEP is perceived as important by participants, at the expense of longer distance to the patient's face and physiologic monitors. In comparison, limited space restricting team leaders' movement at the HEP was offset by proximity to the patient and monitors, allowing for easier patient assessment, monitor visualization and the ability to access and operate key equipment.

Finally, our study demonstrated the use and value of simulation in evaluating specific clinical skills and performance parameters which extremely challenging if not impossible to evaluate in real-life resuscitation. This study clearly demonstrates the effective application of simulation-based research methods to advance knowledge of, understand, and evaluate clinician performance factors which hopefully lead to improved patient care.

4.1. Limitations and suggestions

We enrolled only 34 participants of the planned sample size estimate of 37 due to scheduling and logistics factors, which may have limited our ability to detect differences. Subjects were primarily emergency medicine residents, and did not include ACLS providers from other specialties such as anesthesiology, cardiology, and others. A more diverse physician specialty cohort would help to generalize the applicability of our results.

Secondly, scoring of participants was based on subjective real-time visual assessment. No objective established quality CPR (Q-CPR) performance metrics such as chest compression rate, compression depth, ventilation rate, or hands-off ratio was incorporated into the assessment. These Q-CPR metrics if collected may have generated more objective assessor scoring and provide a more accurate and reliable assessment of the team leader performance. The relatively large performance gap consistently measured by two assessors which was revealed in our finding of relatively low performance scores, should be viewed in the context of the RCC scoring method, and compared to quality of CPR (Q-CPR) performance standards in future validation studies.

Weakness associated with the RCC was identified. In the SA domain, points were allocated to detection of patient's cessation of breathing during scenario transition to cardiopulmonary arrest, and to detection of re-initiation of breathing when return of spontaneous circulation was achieved. Some participants did not verbalize recognition of apnea or resumption of breathing although it was detected. This lack of a clear and consistent observable assessment point lead to lack of clarity for assessors, who completed assessment based on RTL actions which inferred recognition of changes in breathing status.

We recognize that both scenarios incorporated similar ACLS concepts, and that participant performance might reflect a learning effect, with improvement with repeated resuscitation scenario experiences. Additionally, this study was subject to the possible impact of the Hawthorne effect; awareness of being observed may cause behavioral changes and influence team leader performance, impacting generalizability of findings to real-world conditions.[31] This limitation was partly addressed by randomization of participants to the 2 position, assuring equal numbers of participants were assigned to the two positions as the first resuscitation scenario.

In depth assessment of non-technical skills like communication, team co-ordination and leadership aptitudes were beyond the scope of this study. Since previous studies of team leader non-technical skills have an established positive influence on team performance, it would have been interesting to examine whether team leader positioning has any bearing on non-technical skills. We hypothesize that positioning may impact the efficacy of RTL's verbal and non-verbal communications with team members. We did not assess any clinical outcome since this is a simulation-based study. Lastly, the findings of this study are constrained to adult cardiopulmonary arrest scenarios and may not be applicable in trauma or pediatric resuscitations. We believe our findings merit consideration of future studies of team leader positioning in non-ACLS based resuscitation.

A multi-center simulated resuscitation study with bigger sample size that involves participants from multiple specialties may demonstrate a statistically significant difference in performance between the different physical positions of a team leader. Second, expanding the team leader positioning research to include 4 different positions, left and right sides of the patient in addition to head-end and leg-end positions may reveal different findings. The RCC upon which the assessment was based upon can be further improved through external validation, incorporation of team communication elements, and inclusion of objective QCPR measurements to improve inter-rater reliability. Lastly, further studies should evaluate the proximity of the RTL to the patient and ascertain the significance of positioning the team leader within the inner circle.

5. Conclusion

Physical positioning of team leaders during simulated ACLS-based resuscitation scenarios does not appear to be a determinant of team leaders' measured performance parameters including situational attentiveness, ED and DM. We also found that the perception of performance had no significant correlation with actual measured team leader performance. Team leaders however generally scored higher marks across all 3 parameters for performance at the head-end position compared to leg-end position, this trend was albeit not statistically significant. Monitor-displayed critical patient status changes were better detected as compared to patient-based changes or errors. Our findings regarding similar performance at each position, support individual RTL preference when choosing position during resuscitation. Awareness of limitations and advantages of each position may guide an RTL to select optimal positioning during resuscitation.

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Author contributions

Conceptualization: Ismail Mohd Saiboon, Benjamin Berg.
Data curation: Ismail Mohd Saiboon, Farah Nuradhwa Apoo, Shamsuriani Md. Jamal, Afliza Abu Bakar, Fadzlon Mohd Yatim, Mohd Johar Jaafar.
Formal analysis: Ismail Mohd Saiboon, Farah Nuradhwa Apoo, Afliza Abu Bakar, Benjamin Berg.
Funding acquisition: Ismail Mohd Saiboon.
Investigation: Ismail Mohd Saiboon, Shamsuriani Md. Jamal, Afliza Abu Bakar, Fadzlon Mohd Yatim, Mohd Johar Jaafar.
Methodology: Ismail Mohd Saiboon, Farah Nuradhwa Apoo, Shamsuriani Md. Jamal, Afliza Abu Bakar, Fadzlon Mohd Yatim, Mohd Johar Jaafar, Benjamin Berg.
Project administration: Ismail Mohd Saiboon.
Resources: Farah Nuradhwa Apoo.
Supervision: Ismail Mohd Saiboon.
Validation: Ismail Mohd Saiboon.
Writing – original draft: Ismail Mohd Saiboon, Farah Nuradhwa Apoo, Afliza Abu Bakar.
Writing – review & editing: Ismail Mohd Saiboon, Farah Nuradhwa Apoo, Shamsuriani Md. Jamal, Afliza Abu Bakar, Fadzlon Mohd Yatim, Mohd Johar Jaafar, Benjamin Berg.
Ismail Mohd Saiboon orcid: 0000-0003-3972-9803.

References

[1] Marsch SC, Muller C, Marquardt K, et al. Human factors affect the quality of cardiopulmonary resuscitation in simulated cardiac arrests. Resuscitation 2004;60:51–6.
[2] Hunziker S, Tschan F, Semmer NK, et al. Importance of leadership in cardiac arrest situations: from simulation to real-life and back. Swiss Med Wkly 2013;143:w13774.
[3] Schenarts PJ. Incorporating leadership training, a horizontal approach to resuscitation and performance feedback, into advanced life support. Crit Care Med 2007;35:1781–2.
[4] Shetty P, Cohen T, Patel B, et al. The cognitive basis of effective team performance: features of failure and success in simulated cardiac resuscitation. AMIA Annu Symp Proc 2009;2009:599–603.
[5] Schenarts PJ, Cohen KC. The leadership vacuum in resuscitative medicine. Crit Care Med 2010;38:1216–7.
[6] Bhanji F, Mancini ME, Sinz E, et al. Part 16: education, implementation, and teams: 2010 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care. Circulation 2010;122(18 Suppl 3):S920–33.
[7] Kleinman ME, Chameides L, Schexnayder SM, et al. Part 14: pediatric advanced life support: 2010 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care. Circulation 2010;122(18 Suppl 3):S876–908.
[8] Cooper S, Wakelam A. Leadership of resuscitation teams: "Lighthouse Leadership". Resuscitation 1999;42:27–45.
[9] Thomas EJ, Sexton JB, Lasky RE, et al. Teamwork and quality during neonatal care in the delivery room. J Perinatol 2006;26:163–9.
[10] Thomas EJ, Taggart B, Crandell S, et al. Teaching teamwork during the Neonatal Resuscitation Program: a randomized trial. J Perinatol 2007;27:409–14.
[11] Hoff WS, Reilly PM, Rotondo MF, et al. The importance of the command-physician in trauma resuscitation. J Trauma 1997;43:772–7.
[12] Hunziker S, Buhlmann C, Tschan F, et al. Brief leadership instructions improve cardiopulmonary resuscitation in a high-fidelity simulation: a randomized controlled trial. Crit Care Med 2010;38:1086–91.
[13] Yeung JH, Ong GJ, Davies RP, et al. Factors affecting team leadership skills and their relationships with quality cardiopulmonary resuscitation. Crit Care Med 2012;40:2617–21.
[14] Briggs A, Raja AS, Joyce MF, et al. 2015. The role of nontechnical skills in trauma resuscitation. J Surg Educ 2015;72:732–9.
[15] Samuel M, Wieteska S. Advanced Paediatrics Life Support. A Practical Approach to Emergencies. 6th ed.Oxford: Wiley-Blackwell; 2016. 27.
[16] Prince CR, Hines EJ, Chyou PH, et al. Finding the key to a better code. Code team restructure to improve team performance and outcomes. J Clin Med Res 2014;12:47–57.
[17] Cabanas JG, Hinchey PR. Resuscitation and Post Resuscitation Care. 2013. Available at: http://www.frems.com/blog/wp.../Resuscitation-and-Post-Resuscitation-Care.05.28.13.pptx. Powerpoint Presentation. Accessed December 7, 2015.
[18] Jones A, Lin Y, Nettel-Aguirre A, et al. Visual assessment of CPR quality during paediatric cardiac arrest: does point of view matter? Resuscitation 2015;90:50–5.
[19] Perkins GD, Stephenson BT, Smith CM, et al. A comparison between over the head and standard cardiopulmonary resuscitation. Resuscitation 2004;61:155–61.
[20] Maisch S, Issleib M, Kuhis B, et al. A comparison between over-the-head and standard cardiopulmonary resuscitation performed by two rescuers: a simulation study. J Emerg Med 2010;39:369–76.
[21] Maisch H, Gamon E, Ilisch E, et al. Comparison of the over-the-head, lateral and alternating positions during cardiopulmonary resuscitation performed by a single rescuer with a bag-gave mask device. Emerg Med J 2011;28:974–8.
[22] Dawson B, Trapp RG. Basic & Clinical Biostatistics. 3rd ed.London: McGraw-Hill; 2001.
[23] American Heart Association. Advanced cardiopulmonary life support provider manual. United States of America. First American Heart Association Printing. 2016.
[24] Fergus I, Craik M. Effect of distractions on memory and cognition: a commentary. Front Psychol 2014;5:841.
[25] Mastroberardino S, Vredeveldt A. Eye-closure increases children's memory accuracy for visual material. Front Psychol 2014;5:241.
[26] Al-Rasheed RS, Devine J, Dunbar-Viveiros JA, et al. Simulation intervention with mannikin-based objective metrics improves CPR instructor chest compression performance skills. Simul Healthc 2013;8:242–50.
[27] Cheng A, Overly F, Kessler D, et al. Perception of CPR quality: influence of CPR feedback, just-in-time CPR training and provider role. Resuscitation 2015;87:44–50.
[28] Andersen PO, Jensen MK, Lippert A, et al. Identifying non-technical skills and barriers for improvement of teamwork in cardiac arrest teams. Resuscitation 2010;81:695–702.
[29] Ford K, Menchine M, Burner E, et al. Leadership and teamwork in trauma and resuscitation. West J Emerg Med 2016;17:549–56.
[30] Hargestam M, Hultin M, Brulin C, et al. Trauma team leaders' non-verbal communication: video registration during trauma team training. Scand J Trauma Resusc Emerg Med 2016;24:37.
[31] Merret F. Reflection on the hawthorne effect. Edu Psychol 2006;26:143–6.