Factors affecting team leadership skills and their relationship with quality of cardiopulmonary resuscitation*

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Objective: This study aims to explore the relationship between team-leadership skills and quality of cardiopulmonary resuscitation in an adult cardiac-arrest simulation. Factors affecting team-leadership skills were also assessed.

Design: Forty advanced life-support providers leading a cardiac arrest team in a standardized cardiac-arrest simulation were videotaped. Background data were collected, including age (in yrs), sex, whether they had received any leadership training in the past, whether they were part of a professional group, the most recent advanced life-support course (in months) they had undergone, advanced life-support instructor/provider status, and whether they had led in any cardiac arrest situation in the preceding 6 months.

Measurements and Main Results: Participants were scored using the Cardiac Arrest Simulation test score and Leadership Behavior Description Questionnaire for leadership skills. Process-focused quality of cardiopulmonary resuscitation data were collected directly from manikin and video recordings. Primary outcomes were complex technical skills (measured as Cardiac Arrest Simulation test score, preshock pause, and hands-off ratio). Secondary outcomes were simple technical skills (chest-compression rate, depth, and ventilation rate). Univariate linear regressions were performed to examine how leadership skills affect quality of cardiopulmonary resuscitation and bivariate correlations elicited factors affecting team-leadership skills.

Teams led by leaders with the best leadership skills performed higher quality cardiopulmonary resuscitation with better technical performance ($R^2 = 0.75$, $p < .001$), shorter preshock pauses ($R^2 = 0.18$, $p < .001$), with lower total hands-off ratio ($R^2 = 0.24$, $p = .01$), and shorter time to first shock ($R^2 = 0.14$, $p = .02$). Leadership skills were not significantly associated with more simple technical skills such as chest-compression rate, depth, and ventilation rate. Prior training in team leader skills was independently associated with better leadership behavior.

Conclusions: There is an association between team leadership skills and cardiac arrest simulation test score, preshock pause, and hands off ratio. Developing leadership skills should be considered an integral part of resuscitation training. (Crit Care Med 2012; 40:2617–2621)

Key Words: cardiac arrests; cardiopulmonary resuscitation; emergency medicine; leadership; simulation

The delivery of high-quality cardiopulmonary resuscitation (CPR) is vital to patient survival from sudden cardiac arrests (1). Observational studies have revealed that the quality of CPR is often below international guideline standards both during training (2) and in clinical practice (3–5). The proportion of time during resuscitation when no chest compressions were performed (also known as hands off ratio) was high, with a reported incidence of 24%–48% (3, 4, 6). Such interruptions cause a fall in aortic pressures and reduced coronary perfusion pressure in animal studies (7). Prolonged interruptions prior to defibrillation (preshock pause) are linked to defibrillation failure (8), reduced return of spontaneous circulation (9, 10), and reduced overall survival (11).

Advanced life support (ALS) comprises complex and simple technical skills. Complex technical skills require high-level interaction between resuscitation team members in multistep processes (e.g., delivering a shock requires the steps of pausing CPR [CPR provider], analyzing electrocardiogram rhythm [team leader], charging defibrillator [defibrillator operator], asking team to stand clear [team leader], delivering shock [defibrillator operator], and resuming CPR [CPR provider]). Simple technical skills, e.g., chest compression and ventilation are tasks undertaken by a single individual in an automated manner. A commonly cited reason for poor-quality technical skill performance is skill decay after initial training (12). More recently, the nontechnical skills of leadership and teamwork have been identified as important contributory factors to technical skill performance (13). Lack of leadership skills and poor teamwork have been linked to poor clinical outcomes in acute medical settings (14, 15).

This study aims to identify the relationship between leadership skills and the quality of complex and simple CPR-associated tasks, and to identify factors associated with leadership skills.

MATERIALS AND METHODS

The study was approved by the Research Ethic Committee (equivalent to Institutional Review Board) (reference 09/H1210/3). Forty ALS providers who served as cardiac arrest team leaders in their clinical practice consented to take part in our study. Demographic and background data of participants were collected, including age, sex, professional group, date of participants’ last ALS course, ALS instructor/provider status, whether the participant had led in any cardiac arrest scenario in

*See also p. 2719.

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the preceding 6 months, and whether they had received any leadership training in the past.

Participants were brief to lead a cardiac arrest team during a single, standardized resuscitation simulation. The team members were three ALS providers who would perform all tasks competently but only when asked. To emulate the common clinical scenario, team members were unknown to the leaders. Scenario information was given to the participant by a member of the research team. All scenarios were run in real time and video-recorded. Utstein-defined process focused quality of CPR data (16) were collected directly in real time from Resusci Anne Advanced Skill trainer manikin (Laerdal Medical, Orpington, Kent, United Kingdom) using Laerdal PC Skill reporting System (Version 2.2.1). Outcome variables were divided into complex and simple technical skills. Complex skills were cardiac arrest simulation test (CASTest) score (CASTest is explained below), presshock pause, hands off ratio (absolute time and proportion of time while chest compressions were not performed), and time to first shock. Simple technical skills were chest compression rate, depth, and ventilation rate.

Two reviewers (R.D., J.Y.) independently reviewed the video footage from each scenario and measured complex technical and leadership skills. The video recordings were reviewed in a random order and technical and leadership skills were scored in separate viewings (blinded to the previous score assignment). Complex technical skill performance was measured using the CASTest (17). CASTest is a validated scoring system designed to capture complex technical skill performance. It assigns scores of 1–4 to each of 25 test domains with higher scores representing better performance. Leadership skills were measured using the Leadership Behavior Description Questionnaire (LBDQ) (18). LBDQ is a widely used measure of leadership behavior originally designed by the Ohio Leadership School. It was adapted by Cooper in 1999 for the resuscitation team dealing with medical emergencies (Table 1). In emergency teams, it is important to establish an effective team structure quickly. The scoring items focus on how well the leader “initiates team structure.” Each rating is also assessed on a rating scale of 0 to 4 (4 = always, 3 = very often, 2 = about as often as not, 1 = seldom, 0 = never) with a range of scores of 0–40.

Statistical Analyses. Statistical analyses were performed using SPSS version 17.0 (IBM Corporation, New York, NY). All statistical tests performed were two-sided and assessed at a 5% significance level. Normality of data were checked using Kolmogorov–Smirnov Z test. Discrete variables are summarized as counts (percentages) and mean (sd) for normally distributed data and median (range) for non-normal data. We computed Cohen’s κ statistic to assess the interrater reliability for the degree of agreement among the raters for the CASTest and LBDQ. Factor analysis was carried out to identify which factors with Eigen value above 1.1 were most important in explaining leadership skills. Statements within a factor were considered for elimination in case they did not contribute to the internal reliability (as measured by Cronbach’s α) of the total factor score.

Univariate analyses were used to relate team leader leadership skills with complex multiphase skills (measured using CASTest score, hands off ratio, presshock pause, and time to first shock) and simple, single-operator tasks (chest compression rate, depth, and ventilation rate). Characteristics of team leaders were assessed using bivariate correlations. Point-Biserial correlations (r) were used when one variable was dichotomous and the other one, continuous. Pearson correlation (r) was used when both variables were continuous. A significance level of 0.05 was used to enter variables and a significance level of 0.10 was used to remove variables from the stepwise regression. At each step all eligible variables are considered for removal or entry. Participants’ characteristics that were significantly and highly correlated with displaying better team leadership skills were entered into stepwise and all explanatory variables left in multivariate regression models. If such variables were dichotomous, these were recoded into dummy variables with code 0 or 1. The study was designed as an exploratory study.

RESULTS

Participants. Table 2 shows the background characteristics of the participants. Twenty-one were male (53%) and the average age was 34 yrs (sd 7.0). Of the 20 medical participants, nine were from general medicine and 11 from critical care. The other 20 (nonmedical) participants comprised six critical care outreach nurses, ten advanced nurse practitioners, and four resuscitation officers. All participants had received their ALS training within last 4 yrs, with 14 ALS instructors (35%) and 26 providers (65%). Seventeen participants (43%) had received some form of formal leadership training in the past.

All participants had previous experience of acting as a cardiac arrest team leader but only 24 (60%) had led as a cardiac arrest team leader in the 6 months preceding the study.

Interrater Reliability. Interrater reliability was high (κ score of 0.861 for LBDQ score and 0.897 for CASTest score). The average of reviewers’ CASTest and LBDQ scores for each participant was used in data analyses. Timings for the quality of CPR variable were calculated from Laerdal PC Skill reporting system software and validated by the timer on video recordings.

Quality of CPR and Leadership Skills. Overall, the quality of CPR was good. Average (sd) chest compression depth was 52.8 (sd 7.1) mm; rate 96.7 (sd 7.5) min⁻¹; ventilation rate 9.7 (sd 1.6) min⁻¹.

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<th>Table 1. Components of leadership behavior description questionnaire score and results of participants (26)</th>
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Table 2. Background characteristics (n = 40)
preshock pause 15.95 (sd 5.54) secs; postshock pause 3.98 (sd 1.50) secs; time to first shock 75.31 (sd 51.78) secs; and compression fraction was 84.1% (sd 4.88%). The average CASTest score was 75.06 (sd 14.37) of a maximum score of 100. Average LBDQ score was 22.25 (sd 7.73). Scores across the ten LBDQ domains are summarized in Table 1.

Leadership Skills Are Related to Complex Technical Skill Performance. There were strong associations between leadership skills and overall technical performance of complex skills measured by CASTest (Table 3). Associations with other complex measures of quality of CPR (preshock pauses, total hands off ratio, and time to first shock) were weaker although statistically significant: There were no significant statistical associations with the simple CPR tasks (chest compression rate, depth, and ventilation rate).

Factor analyses confirmed that all ten LBDQ statements were important in explaining leadership skills and together explained 81.9% of the variance. All LBDQ statements contributed to the consistency of the total score measurement (overall Cronbach’s α was 0.971; Cronbach’s α was always <0.971 if item deleted). This validated our approach of using total LBDQ score as the most accurate measurement of leadership skills.

Factors Influencing Leadership Skills. The following factors were associated with higher team leadership scores on univariate analysis: older age, recent ALS course, ALS instructor status, nonmedical health profession (rather than doctors), and previous leadership training (Table 4). However, when these factors were analyzed in a multivariate stepwise regression, only past leadership training was retained in the model to explain leadership skills in a cardiac arrest simulation (mean 11.57, confidence interval 8.21–14.93, p < .0001). All other factors correlated to leadership skills were excluded in the model and no longer significant. Analysis using all explanatory variables kept in multivariate model yielded similar results (data not shown).

DISCUSSION

The quality of CPR technical skills, preshock pauses, and hands off time are of critical importance in determining patient outcome (4, 8, 10, 11). Our results confirm the positive impact of leadership skills on quality of cardiopulmonary complex technical skills, preshock pause, and hands off time during an adult cardiac arrest simulation. Similar findings of a positive impact of leadership skills on quality of patient care have been observed in acute medical settings (15, 19).

Nontechnical skills that encompass effective team leadership have been extensively evaluated in the aviation industry and have now been employed to improve patient safety (20). Their importance is increasingly recognized across many acute care medical specialties including acute medicine (21), surgery (22), anesthesia (23–25), critical care (26), trauma, and defense medicine (27). In 2010, the International Liaison Committee on Resuscitation recommended that “specific teamwork training, including leadership skills, should be included in courses (28).” The present study found associations between team leadership and measures of complex technical skills. These skills require features of high-functioning teams such as coordination, cooperation, and communication (29). This finding is consistent with that of others who have observed links between leadership and complex technical skills such as time to initiating ALS (30), hands-on ratio (31), and defibrillation timing and quality (30, 31). By contrast, the lack of significant associations with simple technical tasks is consistent with the observations of previous studies (32).

A survey of Advanced Cardiac Life Support trained doctors found that a high proportion of doctors did not feel adequately trained to lead a cardiac arrest, and more than half felt that Advanced Cardiac Life Support course did not equip them with the necessary team leadership skills (33). In a simulation study, Høyer et al observed how junior doctors manage a patient who went into cardiac arrest during an interhospital transfer. The participants were offered help by the paramedic and ambulance driver but the performance of compressions were only delegated in only 32% of cases and partially delegated in 39% of cases. Their study found junior doctors to be competent in their management of cardiac arrests but lacking in leadership attributes such as delegation of tasks and effective communication skills (34).

The present study used a cardiac arrest team whose members had not worked together previously. This is consistent with recent observations, which noted
that cardiac arrest team members at two thirds of hospitals have never met before attending an emergency. The remaining one third had only met informally (35). Hunziker et al (36) compared the performance of unplanned, ad hoc teams with that of preformed teams in a simulated cardiac arrest. Ad hoc teams provided less hands on time during the initial 3 mins (ad hoc 93 [sd 37] secs vs. preformed 124 [sd 33] secs, p < .0001) and were slower to perform the first shock (ad hoc 107 [sd 46] secs, vs. preformed 67 [sd 42] secs p < .0001). Similarly, Marsch et al (13) noted ad hoc teams failed to recognize and defibrillate a simulated ventricular fibrillation cardiac arrest due to lack of leadership, task distribution, and information transfer. The present study demonstrates how effective team leadership skills can overcome some of the limitations of an ad hoc emergency team and can achieve high-quality CPR with effective team function (37).

A good team leader should possess not only leadership skills but also effective communication skills, mutual performance monitoring, maintenance of guidelines, and task management (38, 39). Some researchers have argued that leadership skills are related to personality traits rather than a learned skill (40). The finding in this study of an independent association between previous team-leader training and demonstration of team-leader skills adds support to the concept that team-leadership skills can be taught. This concept is further supported by findings of Hunziker et al (31) who randomized medical students to ALS training with or without additional content on team leadership. They found that students who received 10 mins of leadership instructions had significantly longer hands-on time compared with a group that had received only 10 mins of technical instruction (120 secs, interquartile range 98–135 vs. 87 secs, interquartile range 61–108, p < .001). The leadership instruction group also started chest compressions and ventilations sooner. Cooper (18) also showed that a 75-min instruction on team leadership qualities improved leadership qualities during a resuscitation simulation. Similar positive results in improved leadership behavior and teamwork were also reported in pediatric 41 and neonatal resuscitation (42).

This study has a number of limitations. The study was an exploratory study with a small sample size that had sufficient power to detect moderate rather than small changes in CPR performance. The study was conducted in a patient simulation laboratory, which serves as a safe environment for studying human behavior (43–45). However, it is possible that behaviors were modified by participants being aware that they were being video-taped (46).

The observed behaviors related to a single, standardized cardiac arrest simulation. It is possible that different situations (e.g., failed intubation and difficult venous access) could have produced different effects on team leader behaviors. There are other measures of nontechnical skills (22, 23, 47) but the authors chose the LBDQ score to focus on the leadership skills of the team leader of cardiac arrest team. The design of our study did not allow for in-depth investigation of the complex relationships and interactions of human behavior such as attitudes, beliefs, motivation, and personality traits all of which influence team performance. Instead, our study demonstrated how the leadership behavior of the team leader can positively influence quality of CPR. It is possible that linearity between team leader skills and another unmeasured confounding variable among the heterogeneous group of participants could exist. The strong association between leadership skills and technical skills as well as the nonrandomized experimental study design meant that the study could neither state the added benefits of nontechnical skills on outcome of the CPR, nor give an idea of the outcome itself on the basis of the amount and/or duration of leadership training that was received. Future research is needed in this area to replicate the results in a larger study with a different experimental design.

CONCLUSIONS

Teams led by leaders with good team leadership skills are associated with shorter pre-shock pauses, shorter hands-off ratio, and better overall performance during simulated cardiac arrests. The encouraging findings in this study suggest that leadership skills can be taught in training and should be considered an integral part of resuscitation training.

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