

# Effect of dyad training on medical students' cardiopulmonary resuscitation performance

Candice Wang<sup>a</sup>, Chin-Chou Huang, MD, PhD<sup>a,c,d,e,\*</sup>, Shing-Jong Lin, MD, PhD<sup>b,c,d,f</sup>, Jaw-Wen Chen, MD<sup>b,c,d,e</sup>

## Abstract

We investigated the effects of dyadic training on medical students' resuscitation performance during cardiopulmonary resuscitation (CPR) training.

We provided students with a 2-hour training session on CPR for simulated cardiac arrest. Student teams were split into double groups (Dyad training groups: Groups A and B) or Single Groups. All groups received 2 CPR simulation rounds. CPR simulation training began with peer demonstration for Group A, and peer observation for Group B. Then the 2 groups switched roles. Single Groups completed CPR simulation without peer observation or demonstration. Teams were then evaluated based on leadership, teamwork, and team member skills.

Group B had the highest first simulation round scores overall ( $P=0.004$ ) and in teamwork ( $P=0.001$ ) and team member skills ( $P=0.031$ ). Group B also had the highest second simulation round scores overall ( $P<0.001$ ) and in leadership ( $P=0.033$ ), teamwork ( $P<0.001$ ), and team member skills ( $P<0.001$ ). In the first simulation, there were no differences between Dyad training groups with those of Single Groups in overall scores, leadership scores, teamwork scores, and team member scores. In the second simulation, Dyad training groups scored higher in overall scores ( $P=0.002$ ), leadership scores ( $P=0.044$ ), teamwork scores ( $P=0.005$ ), and team member scores ( $P=0.008$ ). Dyad training groups also displayed higher improvement in overall scores ( $P=0.010$ ) and team member scores ( $P=0.022$ ).

Dyad training was effective for CPR training. Both peer observation and demonstration for peers in dyad training can improve student resuscitation performance.

**Abbreviations:** ACLS = advanced cardiovascular life support, ANOVA = analysis of variance, CPR = cardiopulmonary resuscitation, EKG = electrocardiography, IV = intravenous.

**Keywords:** cardiopulmonary resuscitation, dyadic training, medical education, simulation

## 1. Introduction

Sudden cardiac arrest is one of the leading causes of death in the world.<sup>[1]</sup> Cardiopulmonary resuscitation (CPR) is a life-saving procedure for cardiac arrest.<sup>[2]</sup> Numerous studies have shown

that improved quality of CPR increases the survival of cardiac arrest patients.<sup>[3–5]</sup> Although the European Resuscitation Council and the American Heart Association have established CPR guidelines and update them regularly,<sup>[6,7]</sup> adherence to advanced cardiovascular life support (ACLS) protocols is still often insufficient, even in well-trained hospital staff.<sup>[8]</sup> This shortcoming is correlated to a decreased return of spontaneous circulation in patients with cardiac arrest.<sup>[9]</sup> During CPR training of medical students, it is important to optimize their CPR learning experience to prepare them to effectively treat cardiac arrest.<sup>[10]</sup>

Dyad training, which entails cooperative learning in pairs, has shown to improve student learning experiences.<sup>[11–18]</sup> Furthermore, it has been shown to have positive effects during clinical skills training, often improving student performance, understanding, or confidence.<sup>[11–14]</sup> A large component of the success of dyad training may be the opportunity to observe peers. In one study, second-year medical students who were taught physical examination skills in either triads or singly had the highest performance in multiple-student conditions, and this improvement was attributed to observation and learning through modeling.<sup>[19]</sup> Similar results were found in a more specified study for neurological physical examinations for lower back pain.<sup>[20]</sup> One of the possible mechanisms of cooperative learning and peer observation that make them beneficial for student learning is the opportunity to observe peers modeling a performance, especially when high-performing peers are observed.<sup>[20]</sup> However, as some have noted, the most effective setting for dyadic training, with respect to learning objective, student population, and subject or skills presented, remains ambiguous.<sup>[15,18]</sup>

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<sup>a</sup> Department of Medical Education, <sup>b</sup> Department of Medical Research, <sup>c</sup> Department of Medicine, Division of Cardiology, Taipei Veterans General Hospital, <sup>d</sup> Cardiovascular Research Center, <sup>e</sup> Institute of Pharmacology, <sup>f</sup> Institute of Clinical Medicine, National Yang-Ming University, Taipei, Taiwan, R.O.C.

\* Correspondence: Chin-Chou Huang, Department of Medical Education, Taipei Veterans General Hospital, National Yang-Ming University, No. 201, Sec. 2, Shih-Pai Road, Taipei 111, Taiwan, R.O.C (e-mail: cchuang4@vghtpe.gov.tw).

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CPR is a team effort during which team members must cooperate to perform various tasks at the same time (such as chest compression, ambu bagging, defibrillation, among others). In addition to the technical skills necessary to accomplish this, nontechnical skills such as leadership and teamwork are also important components for the success of CPR. Multiple team members must not only work simultaneously, but must also understand each other's CPR roles to reach their objective in a limited time frame. Each CPR team thus functions as 1 unit. Whether or not dyadic training—training 2 teams together—is beneficial for CPR education and simulations is still unknown.

The overall goal of our study was to investigate the effects of dyadic training on medical students' resuscitation performance during CPR training for simulated cardiac arrest. We also investigated the effects of the sequence of peer observation, debriefing, and demonstration for peers. The findings of our study will help us improve CPR training quality for medical students.

## 2. Methods

### 2.1. Participants

We recruited 5<sup>th</sup>- to 7<sup>th</sup>-year medical students to participate in our advanced CPR training program at Taipei Veterans General Hospital, Taipei, Taiwan, between 2010 and 2013.

### 2.2. Design

We provided students with a 2-hour training session on advanced CPR for simulated cardiac arrest. During each class, we divided students into teams, each consisting of 4 to 6 team members. Double teams (Dyad training groups) in the training session were named "Group A" and "Group B," respectively. If there was only 1 team in the training session, they were named "Single Groups."

During the training session, all teams received instructions from an attending physician about the foundations of CPR for cardiac arrest and were shown an instructional resuscitation video stressing the importance of leadership, teamwork, and team member skills. All the student groups also received 2 rounds of CPR simulation followed by class discussion. The class discussion consisted of questions and comments from the attending physician and students. For Dyad training groups (Groups A and B), both the demonstrational and observing teams were involved in the debriefing with an attending physician. Single Groups were engaged in discussion with only an attending physician. Students thus worked with each other and the attending physician to analyze the strengths and weaknesses of students' CPR performances.

For Dyad training groups in the training session, the order of CPR simulations was as follows: Group A (first simulation round), Group B (first simulation round), Group A (second simulation round), and then Group B (second simulation round) (Fig. 1). Single Groups also received 2 CPR simulations (first and

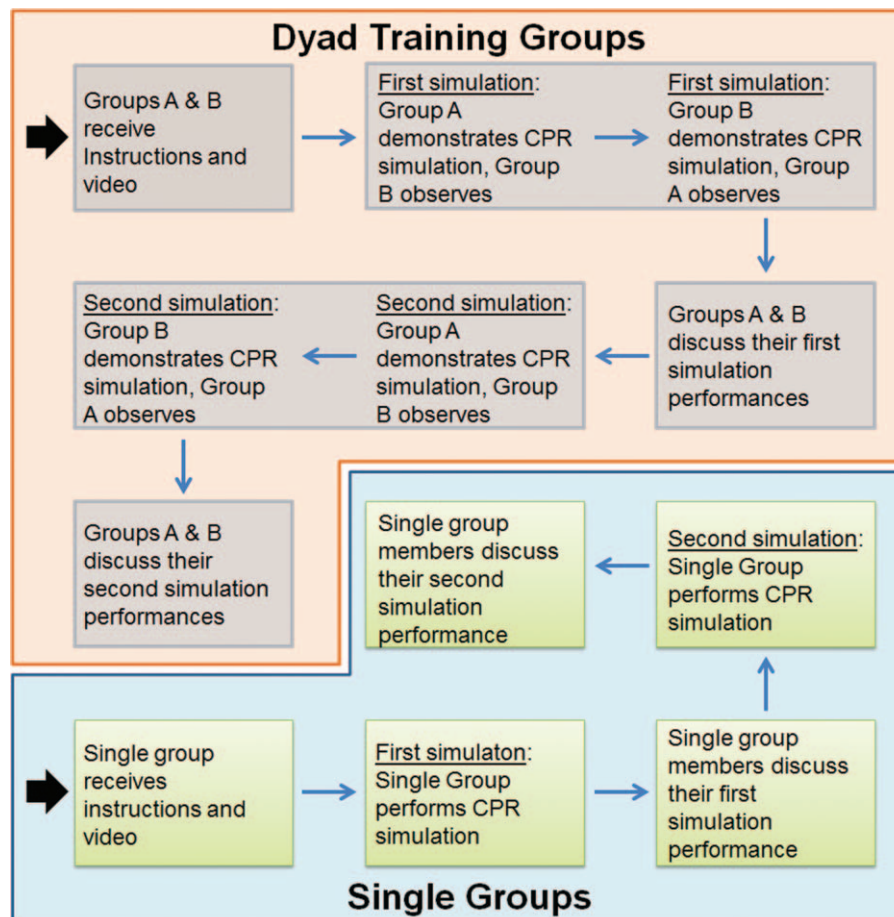


Figure 1. Flow chart of the study.

second simulation rounds), but lacked the opportunity to demonstrate the simulations for peers or to observe peers' simulations (Fig. 1).

Although there were 4 different scenarios of in-hospital cardiac arrest during the training session, all scenarios included ventricular fibrillation/ventricular tachycardia and pulseless-electrical-activity/asystole. Therefore, the CPR procedures were similar for the 4 scenarios. All CPR simulations were practiced using a high fidelity simulator (SimMan, Laerdal Medical Corporation, NY).

The study protocol was exempt from review by the ethics committee of Taipei Veterans General Hospital. All results have been reported in an anonymous fashion and pose minimal risk to the students of the study.

### 2.3. Real-time evaluation

Evaluation processes for the first and second simulation rounds were the same. Our attending physician graded medical student teams from the observation room as they performed CPR simulations. He assessed each team as 1 unit with checklist rating scores using a formal evaluation form.

The checklist rating form was comprised of 20 items in 3 categories: leadership, teamwork, and team member skills. The checklist rating scores ranged from 1 to 5 for each item (1 was the lowest score and 5 was the highest score).

The leadership category consisted of: organization (ability to designate roles to team members such as chest compression, oxygen delivery, defibrillation, intravenous [IV] medication, and recording), order-giving (ability to give orders to team members, communicating the necessary timing and sequence of their actions), support (ability to aid team members in their various roles), and awareness (ability to perceive the situation and understand what actions must be taken).

The teamwork category consisted of: communication (ability to effectively communicate with and deliver clear, concise messages to teammates), cooperation (ability to cohesively work with teammates to achieve a common goal using patience, understanding, and respect), experience-sharing (ability to share the simulation experience with fellow teammates), orderliness (ability to act efficiently and in an organized manner), ACLS principle adherence (ability to follow ACLS guidelines and protocols), and task completion (ability to successfully complete the simulation).

The team member category consisted of: patient contact (ability to make initial contact with the patient to determine consciousness and state of mind), chest compression (ability to perform effective chest compressions on patient), airway check (ability to check patient airways for obstructions), oxygen delivery (ability to consistently deliver oxygen to the patient using a Bag Valve Mask), defibrillation (ability to set up and use a defibrillator), intubation (ability to efficiently and successfully intubate the patient), IV medication (ability to inject appropriate medication through the patient's IV), monitoring (ability to monitor patient vital signs), electrocardiography (EKG) recognition (ability to monitor and understand patient EKG outputs), and recording (ability to accurately record events of the simulation, including times for each of the protocol steps, and procedures/medications used).

The evaluation form is an observational tool. The content validity was established by 1 cardiologist, 1 emergency physician, 1 intensive care physician, and 1 nursing specialist at our institute (Appendix 1, <http://links.lww.com/MD/B626>).

### 2.4. Data processing and analysis

We recorded all of the examinees' evaluation results inclusively and compared them statistically using SPSS version 15.0 software (SPSS Inc, Chicago, IL). Baseline parametric continuous data (student numbers in each team) between the 3 groups were compared using a 1-way analysis of variance (ANOVA). Categorical variables (sex, degree, and experience on resuscitation, and first aid training) were analyzed using  $\chi^2$  tests or Fisher exact tests. Each checklist rating score was expressed as mean (standard deviation). We performed a 1-way ANOVA to compare the checklist rating scores of first and second CPR simulation rounds in 3 groups (Group A, Group B, and Single Groups). Bonferroni correction was applied for the multiple comparisons. We performed a paired *t* test to compare the checklist rating scores of first and second CPR simulation rounds in each group. We performed Student *t* test to compare the checklist rating scores of first CPR simulation rounds, second CPR stimulation rounds, and the differences between Dyad training group (Group A and Group B) and Single Group scores. We inferred statistical significance based on a 2-sided *P* value of  $<0.05$ .

## 3. Results

### 3.1. Participants

We enrolled 267 medical students (164 male and 103 female) in the study, including 94 7<sup>th</sup>-year medical students, 46 6<sup>th</sup>-year medical students, and 127 5<sup>th</sup>-year medical students. One hundred ninety (71.2%) of them had experience on resuscitation and first aid training. We divided them into 56 teams: 20 teams in Group A, 20 teams in Group B, and 16 teams in Single Groups. The mean student numbers in each team were  $4.9 \pm 0.8$  in Group A,  $4.8 \pm 0.8$  in Group B, and  $4.6 \pm 0.8$  in Single Group ( $P=0.551$ ). There were no differences in the baseline characteristics of the 3 groups (Table 1). Each team completed 2 CPR simulations (first and second CPR simulation rounds) during its 2-hour training session.

### 3.2. Comparing the first CPR simulation scores of Group A, Group B, and Single Groups

When comparing the first CPR simulation scores of the 3 groups, Group B displayed significantly higher overall scores ( $P=0.004$ ), teamwork scores ( $P=0.001$ ), and team member scores ( $P=0.031$ ) (Table 2). When comparing the scores in 2 groups, Group B displayed significantly higher scores than Group A in overall scores ( $P=0.003$ ), teamwork scores ( $P=0.001$ ), and team member scores ( $P=0.027$ ). Group A versus Single Groups and Group B versus Single Groups comparisons yielded no significant differences (Table 2).

Within the teamwork category, Group B had the highest scores in the following subcategories: communication ( $P=0.019$ ), cooperation ( $P=0.022$ ), orderliness ( $P=0.017$ ), and completion ( $P=0.010$ ). Within the team member category, Group B had the highest scores in the following subcategories: check airway ( $P=0.001$ ) and give O<sub>2</sub> ( $P=0.001$ ).

### 3.3. Comparing the second CPR simulation scores of Group A, Group B, and Single Groups

When comparing the second CPR simulation scores of the 3 groups, Group B had the highest overall scores ( $P<0.001$ ),

**Table 1****Comparing the baseline characteristics of Group A, Group B, and Single Groups (n=20, n=20, n=16).**

	Group A (n=20)	Group B (n=20)	Group C (n=16)	F	P
Student numbers in each team	4.9±0.8	4.8±0.8	4.6±0.8	0.603	0.551
Sex, n (%)					0.771
Male	58 (59.8%)	58 (60.4%)	48 (64.9%)		
Female	39 (40.2%)	38 (39.6%)	26 (35.1%)		
Degree, n (%)					0.063
Year 7	30 (30.9%)	28 (29.2%)	36 (48.6%)		
Year 6	18 (18.6%)	16 (16.7%)	12 (16.2%)		
Year 5	49 (50.5%)	52 (54.2%)	26 (35.1%)		
Experience on resuscitation and first aid training, n (%)					0.778
Yes	68 (70.1%)	67 (69.8%)	55 (74.3%)		
No	29 (29.9%)	29 (30.2%)	19 (25.7%)		

Student numbers in each team: Group A vs. Group B,  $P=1.000$ ; Group A vs. Single Groups,  $P=0.903$ ; Group B vs. Single Groups,  $P=1.000$ .**Table 2****Comparing first simulation round scores of Group A, Group B, and Single Groups (n=20, n=20, n=16).**

	Group	N	Mean	SD	Minimum	Maximum	F	P
Overall	Group A	20	2.4	0.4	1.8	3.1	6.207	0.004
	Group B	20	2.8	0.3	2.1	3.4		
	Single Group	16	2.6	0.4	1.6	3.2		
Leadership	Group A	20	2.4	0.5	1.5	3.3	2.208	0.120
	Group B	20	2.7	0.6	2.0	3.8		
	Single Group	16	2.6	0.6	1.0	3.5		
Teamwork	Group A	20	2.4	0.4	1.8	3.0	7.471	0.001
	Group B	20	2.9	0.3	2.2	3.7		
	Single Group	16	2.6	0.6	1.5	3.8		
Team member	Group A	20	2.4	0.4	1.7	3.1	3.699	0.031
	Group B	20	2.7	0.4	2.0	3.7		
	Single Group	16	2.5	0.4	1.7	3.2		

SD = standard deviation. Note: overall (Group A vs. Group B,  $P=0.003$ ; Group A vs. Single Groups,  $P=0.516$ ; Group B vs. Single Groups,  $P=0.179$ ); teamwork (Group A vs. Group B,  $P=0.001$ ; Group A vs. Single Groups,  $P=0.703$ ; Group B vs. Single Groups,  $P=0.062$ ); team member (Group A vs. Group B,  $P=0.027$ ; Group A vs. Single Groups,  $P=0.795$ ; Group B vs. Single Groups,  $P=0.474$ ).

leadership scores ( $P=0.033$ ), teamwork scores ( $P<0.001$ ), and team member scores ( $P<0.001$ ) (Table 3). When comparing scores between 2 groups, Group B displayed significantly higher scores than Group A in overall scores ( $P=0.001$ ) and team member scores ( $P<0.001$ ); Group B displayed significantly higher scores than Single Groups in overall scores ( $P<0.001$ ),

leadership scores ( $P=0.029$ ), teamwork scores ( $P<0.001$ ), and team member scores ( $P<0.001$ ). There were no differences between Group A and Single Group scores (Table 3).

Within the leadership category, Group B had the highest scores in the subcategory of awareness ( $P=0.023$ ). Within the teamwork category, Group B had the highest scores in the

**Table 3****Comparing second simulation round scores of Group A, Group B, and Single Groups (n=20, n=20, n=16).**

	Group	N	Mean	SD	Minimum	Maximum	F	P
Overall	Group A	20	3.0	0.3	2.6	3.8	15.187	<0.001
	Group B	20	3.4	0.3	2.9	3.9		
	Single Group	16	2.9	0.3	2.2	3.5		
Leadership	Group A	20	3.2	0.5	1.8	4.0	3.639	0.033
	Group B	20	3.4	0.4	3.0	4.3		
	Single Group	16	3.0	0.5	2.0	3.8		
Teamwork	Group A	20	3.3	0.3	2.7	4.0	9.000	<0.001
	Group B	20	3.6	0.3	3.0	4.0		
	Single Group	16	3.1	0.5	2.0	3.8		
Team member	Group A	20	2.8	0.3	2.3	3.5	16.557	<0.001
	Group B	20	3.2	0.3	2.7	3.7		
	Single Group	16	2.7	0.4	1.8	3.3		

SD = standard deviation. Note: overall (Group A vs. Group B,  $P=0.001$ ; Group A vs. Single Groups,  $P=0.311$ ; Group B vs. Single Groups,  $P<0.001$ ); leadership (Group A vs. Group B,  $P=0.462$ ; Group A vs. Single Groups,  $P=0.570$ ; Group B vs. Single Groups,  $P=0.029$ ); teamwork (Group A vs. Group B,  $P=0.089$ ; Group A vs. Single Groups,  $P=0.114$ ; Group B vs. Single Groups,  $P<0.001$ ); team member (Group A vs. Group B,  $P<0.001$ ; Group A vs. Single Groups,  $P>0.999$ ; Group B vs. Single Groups,  $P<0.001$ ).



following subcategories: orderliness ( $P=0.017$ ), following ACLS principles ( $P=0.004$ ), and completion ( $P=0.001$ ). Within the team member category, Group B had the highest scores in the following subcategories: contact patient ( $P=0.047$ ), defibrillation ( $P=0.015$ ), EKG recognition ( $P=0.001$ ), and recording ( $P=0.046$ ).

### 3.4. Comparing the improvement between first and second simulation rounds among Group A, Group B, and Single Groups

The overall second simulation round scores were significantly higher than first simulation round scores in Group A ( $P<0.001$ ), Group B ( $P<0.001$ ), and Single Groups ( $P=0.005$ ). In Group A and Group B, second simulation round scores were significantly higher than first simulation round scores in leadership ( $P<0.001$  and  $P<0.001$ , respectively), teamwork ( $P<0.001$  and  $P<0.001$ , respectively), and team member categories ( $P=0.004$  and  $P<0.001$ , respectively). In Single Groups, second simulation round scores were significantly higher than first simulation round scores in leadership ( $P=0.005$ ) and teamwork ( $P<0.005$ ), but not team member categories.

When comparing the improvement of CPR simulation scores between the 3 groups, there were differences in overall scores ( $P<0.041$ ) and team member scores ( $P=0.018$ ) (Table 4). When comparing the improvement of overall scores between 2 groups, there were no differences between any 2 groups. When comparing the improvement of teamwork scores between 2 groups, Group A displayed significantly higher improvement than Single Group ( $P=0.016$ ) (Table 4).

### 3.5. Comparing Dyad training group and Single Group performances

When comparing the first CPR simulation performances of Dyad training groups (Group A and Group B) with those of Single Groups, there were no differences in overall scores ( $P=0.776$ ), leadership scores ( $P=0.940$ ), teamwork scores ( $P=0.605$ ), and team member scores ( $P=0.867$ ) (Table 5).

When comparing the second CPR simulation performances of Dyad training groups with those of Single Groups, the former scored higher in overall scores ( $P=0.002$ ), leadership

**Table 5**

**Comparing Dyad training group and Single Group performance (n=40, n=16).**

	Dyad training group (n=40)	Single Group (n=16)	P
First simulation			
Overall	2.6±0.4	2.6±0.4	0.776
Leadership	2.5±0.6	2.6±0.6	0.940
Teamwork	2.7±0.4	2.6±0.6	0.605
Team member	2.6±0.4	2.5±0.4	0.867
Second simulation			
Overall	3.2±0.3	2.9±0.3	0.002
Leadership	3.3±0.4	3.0±0.5	0.044
Teamwork	3.5±0.3	3.1±0.5	0.005
Team member	3.0±0.4	2.7±0.4	0.008
Improvement			
Overall	0.6±0.4	0.3±0.4	0.010
Leadership	0.7±0.7	0.4±0.7	0.106
Teamwork	0.8±0.4	0.5±0.6	0.062
Team member	0.4±0.5	0.2±0.4	0.022

scores ( $P=0.044$ ), teamwork scores ( $P=0.005$ ), and team member scores ( $P=0.008$ ) (Table 5).

When comparing the improvement of Dyad training groups with that of Single Groups, the former showed higher improvements in overall scores ( $P=0.010$ ) and team member scores ( $P=0.022$ ) (Table 5).

## 4. Discussion

The major finding of our study is that dyad training was effective for CPR simulation training—both peer observation and demonstration for peers can improve student resuscitation performance. We further found that initial peer observation in dyad training was the most effective way to optimize student performance in teamwork and team member skills during the subsequent first CPR simulation. Initial peer observation and the subsequent first CPR simulation in dyad training were also the most effective ways to improve student performance in leadership, teamwork, and team member skills during the second CPR simulation.

**Table 4**

**Comparing the improvement between first and second simulation rounds of Group A, Group B, and Single Groups (n=20, n=20, n=16).**

		Mean (difference)	SD (difference)	F	P
Overall	Group A	0.6	0.4	3.407	0.041
	Group B	0.6	0.4		
	Single Group	0.3	0.4		
Leadership	Group A	0.8	0.8	1.637	0.204
	Group B	0.6	0.6		
	Single Group	0.4	0.7		
Teamwork	Group A	0.9	0.4	4.318	0.018
	Group B	0.7	0.4		
	Single Group	0.5	0.6		
Team member	Group A	0.4	0.5	2.725	0.075
	Group B	0.5	0.4		
	Single Group	0.1	0.4		

SD=standard deviation. Note: overall (Group A: Simulation 1 vs. Simulation 2,  $P<0.001$ ; Group B: Simulation 1 vs. Simulation 2,  $P<0.001$ ; Single Groups: Simulation 1 vs. Simulation 2,  $P=0.005$ ). (Group A vs. Group B,  $P=1.000$ ; Group A vs. Single Groups,  $P=0.053$ ; Group B vs. Single Groups,  $P=0.120$ ); leadership (Group A: Simulation 1 vs. Simulation 2,  $P<0.001$ ; Group B: Simulation 1 vs. Simulation 2,  $P<0.001$ ; Single Groups: Simulation 1 vs. Simulation 2,  $P=0.031$ ). (Group A vs. Group B,  $P=1.000$ ; Group A vs. Single Groups,  $P=0.230$ ; Group B vs. Single Groups,  $P=0.834$ ); teamwork (Group A: Simulation 1 vs. Simulation 2,  $P<0.001$ ; Group B: Simulation 1 vs. Simulation 2,  $P<0.001$ ; Single Groups: Simulation 1 vs. Simulation 2,  $P=0.005$ ). (Group A vs. Group B,  $P=0.254$ ; Group A vs. Single Groups,  $P=0.016$ ; Group B vs. Single Groups,  $P=0.652$ ); team member (Group A: Simulation 1 vs. Simulation 2,  $P=0.004$ ; Group B: Simulation 1 vs. Simulation 2,  $P<0.001$ ; Single Groups: Simulation 1 vs. Simulation 2,  $P=0.130$ ). (Group A vs. Group B,  $P=1.000$ ; Group A vs. Single Groups,  $P=0.409$ ; Group B vs. Single Groups,  $P=0.073$ ).

#### **4.1. The effects of dyad training on first simulation round performance**

Many previous studies have shown that dyadic training can improve student performance or confidence in skills.<sup>[11–13,16]</sup> Although some studies indicate no superiority between single and dyadic studies, they note perceived strengths of working with peers, including building communication and cooperation skills.<sup>[14,15]</sup> In Tolsgaard et al's study,<sup>[11]</sup> the peer observation component of dyadic training was perceived by students, who received 1 training session in pairs, to increase learning outcomes during clinical skills education.

In this study, we found that dyadic training was effective for CPR training in medical students. Significant differences in first simulation round checklist rating scores for teamwork and team member categories between Group A, B, and Single Groups indicate that initial peer observation, demonstration for peers, or demonstration for only the attending physician affects student performance during a simulation differently. Specifically, team member skills in airway checking and oxygen delivery were performed best with an initial observation, as was the case with Group B. Teamwork skills in communication, cooperation, orderliness, and completion were also performed best with initial peer observation (Group B). Thus, our study indicated that initial peer observation was the most effective way to optimize student performance during a subsequent first CPR simulation round in teamwork and team member skills.

#### **4.2. The effects of dyad training on second simulation round**

In this study, significant differences in checklist rating scores for leadership, teamwork, and team member categories between Group A, B, and Single Groups during the second simulation round indicates that the sequence and presence of peer observation and demonstration for peers affect skill improvement during CPR training. Leadership skills in awareness were scored highest with initial peer observation followed by the first simulation round (Group B). Similarly, a previous study indicated significantly higher “manager” skills using dyadic training compared with single training.<sup>[12]</sup> Teamwork skills in orderliness, following ACLS principles, and completion were scored highest with initial peer observation followed by the second simulation round (Group B). Team member skills in patient contact, defibrillation, EKG recognition, and recording were scored highest with initial peer observation followed by the second simulation round (Group B). Student performances overall and in team member skills improved more greatly in Dyad training groups than in Single Groups. This was the same case in Shanks et al's study,<sup>[13]</sup> wherein dyad learning produced significantly higher global rating score improvement from the pre-tests to post-tests than directed self-regulated learning. Similar to our results, in another study by Tolsgaard et al, students who received 1 round of clinical skills training were then engaged in simulated patient practice either singly or as dyads, and results indicated that dyads performed significantly better and had greater self-perceived confidence to perform alone in the future.<sup>[12]</sup>

#### **4.3. The possible mechanisms**

This study shows that initial peer observation followed by a first simulation round and initial demonstration for peers during a first simulation round were effective ways to improve students' leadership, teamwork, and team member skills, whereas no

demonstration or observation produced the fewest improvements. This skill improvement may be because of the combination of benefits from peer observation, debriefing, and increased experience after initially completing the first simulation round. These factors then well-prepared students for the second simulation round, wherein lessons learned could be applied, and skills acquired could be showcased. Initial demonstration was also a helpful method for performance and skill improvement because it included all aspects of the peer observation learning model. No demonstration or observation, however, completely lacked any steps in the peer observation learning model, wherein students learn by showing and watching each other, and thus yielded the least successful performance improvement results. In summary, both peer observation followed by demonstration and demonstration followed by peer observation can improve student CPR performance.

#### **4.4. Study limitations**

Our study has some limitations. First, this was an observational study focused mainly on hypothesis generation. Further observation with randomized controlled trials must be conducted in the future. Second, our study results must be considered with acknowledgement of a relatively small sample size. A further study is needed to verify these findings with a larger sample. Third, only a single attending physician who taught the students judged all students' team performance. This may be a potential limitation in terms of the reliability of the checklist rating scores. However, the faculty rater was familiar with the rating scores. We did not find differences in his checklist rating scores during the 3 years of the study, making his judgments consistent. Furthermore, we compared the attending physician's rating scores of 40 simulation rounds with that of 1 nursing practitioner using the same evaluation form in the preliminary status of the study. We found that the rating scores were also consistent between the 2 raters (Appendix 2, <http://links.lww.com/MD/B626>). Fourth, the faculty rater was not blinded because he was the attending physician who taught the students of the study. This however is also one of the limitations of our observational study as a consequence of the faculty to student ratio at the university. Future studies should be conducted with an attending physician who conducts debriefing and discussion with students and another blinded faculty rater. Fifth, we did not divide the students into 3 types of groups in one timeline. When possible, 2 groups would undergo training together (Dyad training Groups), but because of time conflicts and class size limitations, Single Groups were necessarily created on alternate dates and underwent training alone. Because this was an observational study, data were collected based on groups present, and the authors did not intervene to regroup students. A future study could test our findings on 3 groups (Group A/B and Single Groups) in one timeline. Finally, it would be interesting to repeat the same study 3 to 6 months later with the same students in Dyad training Groups using a cross-sectional method where Group B becomes A, Group A becomes B, and single groups remain the same.

## **5. Conclusions**

Dyad training was effective for CPR training. Both peer observation and demonstration for peers in dyad training can improve student resuscitation performance.

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Candice Wang currently attends the College of Osteopathic Medicine of the Pacific, Western University of Health Sciences in Pomona CA. At the time this research was conducted, she was solely affiliated with the Taipei Veterans General Hospital.

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