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ORIGINAL RESEARCH

Study on the application effect of problem-based learning with situational simulation teaching method in cardiopulmonary resuscitation training

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Abstract

This study aimed to explore the application effect of problem-based learning and situational simulation teaching in cardiopulmonary resuscitation (ECPR) education. A retrospective analysis was conducted on 128 trainees specializing in ECPR at our institution. The participants were divided into two groups: a study group and a control group. The study group consisted of 64 students who received problem-based learning with situational simulation, and a control group of 64 students who adopted traditional teaching methods. Comparative analysis was performed between the two groups in terms of theoretical and practical skills scores, Cardiopulmonary resuscitation (CPR) compression quality, self-directed learning ability and satisfaction with the teaching. There was no statistically significant difference between the two groups in the following pre-training measures: self-management ability score, passion for learning score, self-control ability score, compression depth, compression depth efficiency, chest rebound ratio and compression rate ($p > 0.05$). After undergoing training, the study group outperformed the control group in all aspects, including theory, practical skills, compression depth, compression depth efficiency, chest rebound ratio, compression rate, self-management ability, passion for learning and self-control ability. The study group also reported higher satisfaction with the teaching, with a statistically significant difference ($p < 0.05$). We conclude that problem-based learning used in conjunction with situational simulation in CPR training can help trainees enhance their learning abilities, better grasp theoretical and practical knowledge, and improve the quality of CPR practical skills.

Keywords

Problem-based learning; Situational simulation teaching method; Cardiopulmonary resuscitation; Teaching quality; Retrospective analysis

1. Introduction

Cardiac arrest is a severe disorder characterized by the abrupt stopping of the heart's beating, leading to the halt of blood circulation and the deprivation of oxygen and nutrients to the body's organs. The primary cause of cardiac arrest is cardiovascular disease [1]. The prevalence of cardiovascular diseases is increasing in sync with improvements in living standards and changes in lifestyle habits, making them a prominent contributor to the overall disease burden among the Chinese population. Consequently, the frequency of sudden cardiac arrests has increased to around 1600 per day.

The resuscitation success rate is inversely proportional to the delay in time during cardiac arrest. Statistics indicate that for every minute of delay, the success rate of resuscitation decreases by 10%. Thus, a five-minute delay could possibly result in permanent brain injury. A prompt and efficient emergency rescue is therefore necessary. Currently, China has a population of 310 million individuals suffering from cardiovascular diseases, with an average of over 1600 persons encountering cardiac arrest on a daily basis. Statistics indicate that the survival rate of individuals experiencing cardiac arrest in China is approximately 5%, far lower than the rates observed in developed countries and regions [2].

Cardiopulmonary resuscitation (CPR) is an emergency procedure used to revive people experiencing cardiac arrest. Firstly, it mostly involves evaluating awareness, calling for assistance, performing chest compressions, clearing the airway and providing artificial respiration. Furthermore, in the event that the patient loses consciousness, bystanders are promptly directed to contact emergency services (dial 120 in China) and provide accurate details regarding the patient's whereabouts. Next, thoracic compressions is executed to a magnitude of 5–6 cm at a rate of 100–120 per minute and ensured that there are no obstructions in the patient's airway whiles head tilt-chin lift technique is used to facilitate its opening. Additionally, rescue breaths are administered by providing two breaths lasting approximately 1 second each after every 30 chest compressions. The sequence is reiterated. By using these measures, rescuers can extend the duration during which treatment can be administered to the patient, enhance their likelihood of survival and reduce the extent of brain damage caused by oxygen deprivation [3–5].

In order to ensure effective implementation in real-life scenarios, the instruction of CPR, which is an essential proficiency for all medical practitioners, must be conducted in a practical, systematic and logical manner. When educating specialized trainees who already possess a certain level of professional knowledge and a strong desire to learn, it is crucial to adapt teaching methods to their talents while ensuring high-quality instruction within strict time constraints and extreme pressure. This plan aims to enhance their professional growth, enabling them to effectively handle cardiac arrest situations in future emergencies. Traditional teaching methods for medical professionals often encompass textbook lectures, video demonstrations and practice with manikins. Nevertheless, these methods are deficient in terms of incorporating real-life situations, offering inadequate practical experiences, presenting difficulties in evaluating individuals, and restricting interactivity, engagement and enthusiasm [6].

Several approaches are commonly used to improve the quality and efficacy of CPR education and promote greater interaction between teachers and learners. Problem-based learning is a pedagogical approach that is driven by questions, focuses on the student, and combines autonomous investigation, group work, and profound understanding to significantly improve learning outcomes [7]. Situational simulation teaching creates real or near-real life settings for learners to practice and experience, provide strong realism, experiential learning, interactivity, and initiative. This approach significantly improves learning effectiveness and enhances practical skills [8]. The combination of these two approaches can mutually enhance teaching and learning. It allows theoretical knowledge to evolve into clinically relevant and experiential scenarios. Through medical topics and case discussions, issues encountered by students during their learning process can be identified and resolved, thereby enhancing their self-learning and innovation abilities.

The purpose of this study is to investigate the use and efficacy of problem-based learning paired with situational simulation teaching in cardiopulmonary resuscitation education.

2. Study participants and methods

2.1 Study participants

A retrospective analysis was conducted on 128 trainees specializing in ECPR at our institution. According to the training methods, they were divided into a study group and a control group, with 64 participants in each group. There was no statistically significant difference in the general characteristics between the two groups ($p > 0.05$), indicating comparability as seen in Table 1.

2.2 Inclusion and exclusion criteria

2.2.1 Inclusion criteria

1. No previous training in cardiopulmonary resuscitation (CPR) other than at our institution.
2. Good physical health.

2.2.2 Exclusion criteria

1. Incomplete data.
2. Withdrawal during the study.

2.3 Methods

Both groups of trainees were taught by the same group of teachers experienced in CPR. The training duration was set at 6 hours (for 3 months) for each group.

The study group employed problem-based learning and situational simulation teaching method:

1. Pre-class preparation: According to the tasks and goals outlined in the "Chinese Expert Consensus on CPR" [9], PowerPoint slides were prepared for students to preview and grasp the content of the training independently before class.

2. Preparation of the training equipment: XY-CPR490 advanced fully automatic computerized CPR model was used to teach the trainees, and the parameters were set according to the relevant teaching scenarios.

3. Teaching organization: trainees were divided into 8 groups and given simulated first-aid scenarios to practice. CPR was performed by the members of the resuscitation group. Each scenario had a 20-minute teaching period. The instructor took pictures and videos throughout the training and guided the students as they completed the exercise in groups.

4. Post-course evaluation: the teachers guided the trainee students in researching, debating and summarizing the assessment standards and contents while extending and applying them in real-world clinical cases. This helped the trainees gain

TABLE 1. Comparison of general information between the two groups.

Group	Gender		Age ($\bar{x} \pm$ s, yr)	Educational level	
	Male	Female		College Diploma	Undergraduate and above
Study group	31	33	24.83 ± 2.60	13	51
Control group	32	32	25.32 ± 2.55	14	50
χ^2/t	0.031		0.942	0.047	
p value	0.860		0.176	0.828	

a deeper understanding of the material and build up a portfolio of knowledge, as well as assess their learning and the lecturers' instruction.

2.4 Observation indicators

1. Theory and operation skills achievement: the theoretical knowledge assessment was based on the task objectives of the Chinese CPR Expert Consensus. The exam paper was designed to include 100 multiple-choice questions, with each question worth 1 point. The operational skills assessment evaluated individual CPR skills before and after training, focusing on preparation before operation, assessment and rescue, chest compressions, artificial respiration, resuscitation quality and humanistic care, each comprising 20 points.

2. CPR compression quality: the quality of CPR compression among trained students, including the average compression depth, the effective rate of compression depth, the full rebound ratio of the chest and the average compression frequency was observed, recorded and compared.

3. Autonomous Learning Ability: the "Self-Directed Learning Readiness Scale" [10] (SDLRS), which includes 40 items evaluating self-management, passion for learning, and self-control, with a maximum score of 200 was used to evaluate trained students.

4. Evaluation of the results of satisfaction with teaching: an anonymous questionnaire (satisfaction, general satisfaction and dissatisfaction) was distributed to evaluate satisfaction with the teaching method. Specific survey contents included teaching recognition, improvement in clinical operations, enhancement of critical thinking, improvement in doctor-patient communication, teamwork improvement and willingness to use the teaching again. Satisfaction rate = (number of satisfied cases + number of generally satisfied cases)/total number of cases $\times$ 100%.

2.5 Statistical analysis

SPSS 24.0 statistical software (IBM Corporation, Armonk, NY, USA) was used to process the relevant data. t-test was used for measurement data, and a χ^2 test was used for count data. $p < 0.05$ was considered a statistically significant difference.

3. Results

3.1 Comparison of theory and operation skill achievement of the two groups

The study group's theoretical and operational skills were improved and higher than that of the control group after training and the difference was statistically significant ($p < 0.05$) as seen in Table 2.

3.2 Comparison of CPR compression quality between the two groups

The study group's average compression depth and effective rate of compression depth were efficient; the full rebound ratio of the chest, and the average compression frequency were all increased and higher than that of the control group after training, and the difference was statistically significant ($p < 0.05$) as seen in Table 3.

3.3 Comparison of the self-management ability of the two groups

The study group's self-management skills, passion for learning and self-control ability scores improved and were higher than those of the control group, and the difference was statistically significant ($p < 0.05$) as seen in Table 4.

3.4 Comparison of the two groups' satisfaction rating with teaching

After training, the study group's satisfaction rate with teaching was higher than that of the control group, and the difference was statistically significant ($p < 0.05$) as seen in Table 5.

4. Discussion

Cardiopulmonary resuscitation (CPR) is a necessary skill that all emergency physicians must possess in order to respond to a cardiac arrest [11]. When a patient goes into cardiac arrest, it is critical to quickly assess the patient's condition, call emergency personnel, perform rhythmic compressions in the middle of the chest, provide artificial respiration to improve survival rates to prevent organ damage, and allow time for subsequent treatment [12]. In order for emergency physicians to provide accurate and efficient CPR in different situations, it is crucial that CPR training is practical, methodical and uniform. Prior instruction mostly emphasized theoretical exposition, video demonstration and instructional models, with minimal engagement in real-life scenarios, task allocation and practical implementation [11]. To compensate for the limitations of traditional teaching and increase the quality and efficiency of CPR instruction, the problem-based learning model and situational simulation teaching technique are frequently employed. This teaching approach can help trainees with problem orientation, introduction of actual situations, and group interaction to enhance their practical ability to a greater extent [13–15].

In this research, the study group focused primarily on enhancing realism, improving problem-solving abilities, and stimulating proactive learning. The program generated a stressful ambiance and stress akin to urgent circumstances by employing extremely lifelike scenarios, with the goal of fostering users' capacity to react. Particular situations were employed to stimulate active investigation and the pursuit of solutions among participants, so increasing their inherent drive to learn cardiopulmonary resuscitation. Comparatively, the combined teaching group demonstrated enhanced theoretical and fundamental operational performance following training, surpassing that of the traditional teaching group. This difference was statistically significant ($p < 0.05$). The combination of problem-based learning mode and situational simulation teaching method demonstrated higher quality and effectiveness in training, possibly due to several reasons compared to traditional teaching methods. The combination of problem-based learning mode and situational simulation teaching method provided higher continuity and promoted

TABLE 2. Comparison of theoretical and operational skills scores between the two groups ($\bar{x} \pm$ s, score).

Indicators	Study group (n = 64)	Control group (n = 64)	*t* value	*p*-value
Theoretical skills				
Before training	69.57 ± 6.96	70.35 ± 6.84	0.639	0.263
After training	86.34 ± 8.67	81.75 ± 8.29	3.061	0.002
t value	12.067	8.486		
p-value	<0.001	<0.001		
Operating skill				
Before training	73.62 ± 7.40	74.31 ± 7.21	0.534	0.298
After training	87.39 ± 8.84	81.86 ± 8.17	3.675	<0.001
t value	9.555	5.543		
p-value	<0.001	<0.001		

TABLE 3. Comparison of the quality of CPR compressions between the two groups ($\bar{x} \pm$ s).

Indicators	Study group (n = 64)	Control group (n = 64)	*t* value	*p*-value
Average compression depth (mm)				
Before training	38.42 ± 3.86	37.67 ± 3.91	1.092	0.140
After training	56.48 ± 5.71	46.64 ± 4.83	10.526	<0.001
t value	20.963	11.548		
p-value	<0.001	<0.001		
The effective rate of compression depth (%)				
Before training	61.88 ± 6.08	60.94 ± 6.19	0.867	0.195
After training	80.04 ± 8.17	72.34 ± 7.28	10.526	<0.001
t value	5.179	14.571		
p-value	<0.001	<0.001		
Full rebound ratio (%)				
Before training	72.38 ± 7.24	73.18 ± 7.13	0.630	0.266
After training	92.47 ± 1.25	81.35 ± 1.16	52.166	<0.001
t value	21.875	9.048		
p-value	<0.001	<0.001		
Average compression frequency (times/min)				
Before training	103.48 ± 10.41	101.85 ± 9.83	0.911	0.184
After training	119.34 ± 12.17	115.34 ± 11.68	1.897	0.032
t value	7.823	7.069		
p-value	<0.001	<0.001		

TABLE 4. Comparison of the independent learning abilities of the two groups ($\bar{x} \pm$ s, score).

Indicators	Study group (n = 64)	Control group (n = 64)	*t* value	*p*-value
Self-management skills				
Before training	51.35 ± 5.14	50.77 ± 5.38	0.623	0.268
After training	60.79 ± 6.08	53.70 ± 5.48	6.930	<0.001
t value	9.486	3.049		
p-value	<0.001	0.002		
Passion for learning				
Before training	44.92 ± 4.50	45.36 ± 4.84	0.533	0.298
After training	54.51 ± 5.67	51.29 ± 5.13	3.369	0.001
t value	10.599	6.726		
p-value	<0.001	<0.001		
Self-control ability				
Before training	51.85 ± 5.28	52.44 ± 5.13	0.641	0.262
After training	70.26 ± 7.08	64.26 ± 6.43	5.019	<0.001
t value	16.676	11.496		
p-value	<0.001	<0.001		

TABLE 5. Comparison of the two groups' satisfaction rating with teaching (n, %).

Group	Number of cases	Satisfied	Generally satisfied	Dissatisfied	Total satisfaction rate
Study group	64	55 (85.94)	8 (12.50)	1 (1.56)	63 (98.44)
Control group	64	41 (64.06)	14 (21.88)	9 (14.06)	55 (85.94)
χ^2 value	—		—		6.942
p-value	—		—		0.008

teamwork. It stimulated trainees' interest in learning, enhanced self-directed learning, improved adaptability, and problem-solving abilities [16].

The combination of problem-based learning mode and situational simulation teaching method was closer to real-life scenarios. In practice, this approach deepened the level of knowledge and understanding and improve the ability to connect theory with practice. Through the introduction of XY-CPR490 advanced fully automatic computer cardiopulmonary resuscitation model, errors such as unclear equipment functions and unclear usage procedures can be avoided. Chest compression depth and compression rate are the most critical evaluation indicators affecting the survival rate of cardiac arrest patients. According to the "2020 American Heart Association CPR and Cardiovascular Emergency Care Guidelines", effective CPR compression depth should be 5–6 cm, and compression rate should be 100–120 compressions per minute. Studies have confirmed that patients receiving CPR with a compression rate of 100–120 compressions per minute have higher survival rates compared to those with a rate ≥120 compressions per minute.

After training, the study group demonstrated superior performance compared to the control group in terms of CPR compression quality. This was evident through significantly higher average compression depth, effective compression depth rate, chest rebound ratio and average compression rate ($p < 0.05$). This may be attributed to the problem-based learning mode used in conjunction with situational simulation teaching method, which enhances trainees' teamwork capabilities. This enabled the participants to clarify their roles and responsibilities quickly and execute tasks according to standard procedures. This method also enhances trainees' psychological resilience and adaptability, enabling them to take timely, accurate and effective rescue measures in various scenarios, thereby buying crucial time for cardiac arrest patients [17]. Problem-based learning prompts students to deepen their understanding of the impact of compression rates on treatment effectiveness. Situational-based teaching creates a realistic and tense atmosphere, increasing student engagement, focus, innate sense of responsibility, participation and initiative.

In the comparison to self-directed learning abilities, the study group showed statistically significantly higher scores in self-management ability, passion for learning ability, and self-control ability after training compared to the control group (*p*

< 0.05). The study group displayed higher levels of coherence, independence and learning effectiveness, which could be attributed to more extensive preceding preparation. Through active participation in the classroom, trainees cultivated self-awareness and actively engaged in problem-solving and learning, resulting in an enhanced effectiveness of positive feedback. Engaging trainees in realistic events during class enhanced their capacity to adjust and manage crises, with a specific emphasis on cultivating remarkable psychological resilience. Through participation in intensive seminars, video replay reflection and discussion and operations, trainees were able to deepen their understanding and proficiency in CPR by applying critical thinking to related problems [18]. In comparing satisfaction evaluation results of teaching, the study group showed a higher satisfaction rate after training than the control group, with differences being statistically significant ($p < 0.05$). One possible reason for this is that the integration of problem-based learning and situational simulation teaching approaches offers enhanced engagement, realism, and learning opportunities.

The study group focuses not on traditional "spoon-feeding" of theory and practical knowledge but on practical application and role-playing, effectively stimulating trainees' initiative, improving clinical operation skills, teamwork and enhancing overall learning experiences [19]. The teachers in the study group prioritize the holistic learning experience of trainees by providing sufficient time for discussion before, during and after class. This approach promotes more advanced clinical thinking and cultivates a positive and enthusiastic learning environment, ultimately improving the overall learning experience [20]. The situational simulation teaching method bridges the gap between trainees and patients or bystanders, enhancing their ability to communicate effectively under pressure and handle unforeseen circumstances.

5. Conclusions

In summary, compared to traditional teaching methods, the problem-based learning mode used in conjunction with situational simulation teaching method in cardiopulmonary resuscitation education helps trainees to enhance their learning abilities, better grasp theoretical and operational knowledge and improve the quality of CPR practical skills. Nevertheless, there are still obstacles to overcome, like the limited scope of information, discrepancies between real-life situations and their practical application, and increased expenses. These shortcomings will be acknowledged and addressed in future teaching practices.

AVAILABILITY OF DATA AND MATERIALS

The authors declare that all data supporting the findings of this study are available within the paper and any raw data can be obtained from the corresponding author upon request.

AUTHOR CONTRIBUTIONS

JY and MFW—designed the study and carried them out; prepared the manuscript for publication and reviewed the draft of the manuscript. JY, MFW, SJX and YLB—interpreted the data. JY, MFW, SJX and YLB—supervised the data collection. JY, MFW and SJX—analyzed the data. All authors have read and approved the manuscript.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Ethical approval was obtained from the Ethics Committee of Nanjing University of Chinese Medicine (Approval no. 2020014). Written informed consent was obtained from all participants.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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