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Enhancing the Application Value of the Medical Simulation Course on "Chest Pain" in Residency Training through the PDCA Cycle Method

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Abstract: *Objective:* To analyze the application of the PDCA cycle method in the residency training teaching of the medical simulation course on "chest pain." *Methods:* Forty-eight residents from the 2023 cohort were selected and divided into a control group (traditional teaching method, 24 residents) and an observation group (PDCA cycle method, 24 residents) based on professional allocation principles. The teaching outcomes of the two groups were compared. *Results:* After teaching, the observation group demonstrated superior performance in departmental assessment scores (theoretical assessment scores, practical skill assessment scores, case analysis scores), critical thinking abilities (truth-seeking, open-mindedness, systematic ability, inquisitiveness, self-confidence, cognitive maturity), and teaching quality (teaching content, teacher-student cooperation, theoretical teaching, practical teaching, teaching methods) compared to the control group (all $P < 0.05$). *Conclusion:* Applying the PDCA cycle method to the residency training teaching of the medical simulation course on chest pain can effectively enhance residents' assessment scores and comprehensive thinking abilities, optimize overall teaching quality, and possess clinical teaching promotion value.

Keywords: Medical simulation course on "chest pain"; Residency training teaching; PDCA cycle method

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1. Introduction

Residency training is a crucial link connecting medical theoretical education with clinical practice, directly determining the clinical competence and quality of medical services provided by young physicians [1]. Chest pain is a high-incidence emergency in clinical emergency and internal medicine departments, characterized by sudden onset, rapid progression, and a high misdiagnosis rate, posing extremely high demands on the rapid assessment and standardized management abilities of residency trainees [2]. Traditional residency

training teaching primarily relies on theoretical lectures combined with clinical observation, resulting in a rigid and monotonous teaching model that leads to inconsistent teaching outcomes and fails to precisely meet the standardized residency training requirements. In recent years, with the continuous development of modern medical education systems, various novel teaching models have been gradually applied to clinical residency training teaching, including flipped classroom teaching, case-based teaching, and scenario simulation teaching, effectively circumventing the shortcomings of traditional teaching [3,4]. Among them, the PDCA cycle method achieves dynamic optimization and continuous improvement of the teaching process through a management model combining planning, execution, inspection, and handling. Currently, systematic research on the application of the PDCA cycle method in the medical simulation residency training course on chest pain is relatively scarce, and a mature, promotable teaching system has not yet been formed. Based on this, this study focused on residency trainees as the research subjects and compared the application effects of traditional teaching and PDCA cycle teaching in the chest pain simulation course.

2. Materials and methods

2.1. General information

According to professional allocation principles, 48 residents from the 2023 cohort were divided into a control group and an observation group, with 24 residents in each group. Control group: 10 males and 14 females; aged 23–30 years, with an average age of 26.22 ± 1.71 years; 16 postgraduates and 8 undergraduates. Observation group: 12 males and 12 females; aged 23–31 years, with an average age of 26.15 ± 1.60 years; 15 postgraduates and 9 undergraduates. The comparison of gender, age, and educational background between the two groups ($P > 0.05$) indicated comparability. This study was approved by the hospital's Medical Ethics Committee. Inclusion criteria: Training majors included internal medicine, emergency medicine, and other chest pain-related clinical majors; full participation in the medical simulation course teaching on chest pain; no prior participation in similar PDCA teaching model training; good physical and mental health; signed informed consent. Exclusion criteria: Absence from training due to leave, rotation adjustments, or external study; presence of basic clinical ability deficiencies that prevent completion of course assessments; concurrent severe somatic diseases; significant disparities in basic learning abilities; simultaneous participation in other residency training teaching research.

2.2. Methods

Control group (traditional teaching method): Instructors delivered theoretical lectures based on the department's established teaching syllabus, focusing on common and critical conditions related to acute chest pain. They systematically explained the fundamental diagnostic and therapeutic knowledge of diseases such as acute myocardial infarction, pulmonary embolism, and aortic dissection. The classroom teaching primarily consisted of one-way lectures, supplemented by the instructors' organization of key diagnostic and therapeutic points, differential diagnosis strategies, and common clinical misconceptions based on their past clinical experience. After class, routine learning tasks were assigned, requiring students to independently review knowledge points, consult clinical guidelines, and examine case records. Skill acquisition relied on daily clinical rotations, where students followed instructors in receiving, examining, and performing basic diagnostic and therapeutic procedures on patients with chest pain.

Observation group (PDCA cycle method): A systematic simulation teaching system was constructed based on acute life-threatening chest pain diseases, including four core conditions: acute myocardial infarction, aortic dissection, tension pneumothorax, and pulmonary embolism. Specialized teaching was conducted for internal medicine, surgery, and emergency medicine residency trainees, divided into four stages throughout the process. (1) Planning Stage (Plan): Teaching needs analysis was conducted at the hospital, department, and trainee levels using the Goldstein model, aligning with the standardized residency training requirements. The core objectives of the chest pain-specific teaching were clarified, focusing on cultivating students' abilities in history taking, physical examination, interpretation of auxiliary examinations, emergency procedures, disease assessment, and doctor-patient communication. Instructors wrote customized lesson plans based on typical clinical cases, establishing a standardized framework for the chest pain simulation course, specifying teaching content, methods, and assessment criteria. (2) Implementation Stage (Do): A blended learning model combining online preview and offline scenario simulation was adopted. Theoretical knowledge and skill operation videos were disseminated through the medical education cloud platform, encouraging students to engage in pre-class self-study. The classroom focused on case-based learning (CBL) and team-based learning (TBL), with standardized patients and simulation teaching aids used to create authentic clinical scenarios. Students were guided through case analysis, differential diagnosis, treatment plan formulation, and medical record writing in strict accordance with the SOAP diagnostic and therapeutic process, with all sessions recorded for review. After teaching, the GAS debriefing model was employed to guide students in organizing operational issues and summarizing diagnostic and therapeutic approaches. The course adopted a small-class format of six students per session, with weekly specialized simulation training sessions to ensure teaching quality. (3) Check Stage (Check): Each week's teaching cycle served as a comprehensive assessment period. Subjective evaluations were collected through questionnaires to gather student feedback on course experience, learning satisfaction, and suggestions for teaching improvement, assessing course difficulty and teaching practicality. Objective assessments utilized the Objective Structured Clinical Examination (OSCE) model, incorporating written theoretical exams, skill operation assessments, and case analysis evaluations to comprehensively evaluate students' stage-specific learning outcomes. (4) Improvement and Action Stage (Act): After teaching, a bidirectional debriefing session was conducted between teachers and students. Teachers identified shortcomings in the teaching process, while students summarized learning gaps and practical deficiencies. Based on assessment results and feedback, course cases, teaching processes, and practical emphasis were targeted for optimization, refining the teaching plan to seamlessly transition into the next PDCA teaching cycle.

2.3. Observation indicators

Departmental assessment scores: Theoretical assessment scores, skill operation assessment scores, and case analysis scores. Higher scores indicate better assessment performance.

Critical thinking abilities: Truth-seeking, open-mindedness, systematic ability, inquisitiveness, self-confidence, and cognitive maturity. Higher scores indicate better critical thinking abilities.

Teaching quality: Teaching content, teacher-student cooperation, theoretical teaching, practical teaching, and teaching methods. Higher scores indicate better teaching quality.

2.4. Statistical methods

Data were analyzed using SPSS 27.0 statistical software. Count data were expressed as [number of cases (%)] and tested using the chi-square test. Measurement data were expressed as mean ± standard deviation (SD) and tested using the *t*-test. A *P*-value < 0.05 was considered statistically significant.

3. Results

3.1. Comparison of departmental assessment scores between the two groups

The observation group demonstrated superior departmental assessment scores compared to the control group ($P < 0.05$). See **Table 1**.

Table 1. Comparison of departmental assessment scores between the two groups (mean ± SD, points)

Group	*n*	Theoretical examination score	Practical skill examination score	Case analysis score
Observation group	24	34.12 ± 2.11	23.96 ± 1.82	25.66 ± 1.51
Control group	24	31.50 ± 2.53	22.03 ± 1.97	22.79 ± 1.68
t		3.896	3.525	6.224
P		<0.001	0.001	<0.001

3.2. Comparison of critical thinking abilities between the two groups

The observation group demonstrated superior critical thinking abilities compared to the control group ($P < 0.05$). See **Table 2**.

Table 2. Comparison of critical thinking abilities between the two groups (mean ± SD, points)

Group	*n*	Truth-seeking	Open-mindedness	Systematicity	Inquisitiveness	Self-confidence	Cognitive maturity
Observation group	24	45.28 ± 5.38	44.25 ± 4.62	43.28 ± 4.75	45.89 ± 5.23	44.57 ± 3.96	45.34 ± 6.20
Control group	24	35.63 ± 5.42	39.21 ± 4.85	36.52 ± 5.43	40.72 ± 6.43	34.81 ± 4.77	39.62 ± 6.95
t		6.190	3.686	4.590	3.056	7.712	3.009
P		<0.001	0.001	<0.001	0.004	<0.001	0.004

3.3. Comparison of teaching quality between the two groups

The observation group exhibited superior teaching quality compared to the control group ($P < 0.05$). See **Table 3**.

Table 3. Comparison of teaching quality between the two groups (mean ± SD, points)

Group	*n*	Teaching content	Teacher-student collaboration	Theoretical teaching	Practical teaching	Teaching method
Observation group	24	24.09 ± 0.42	24.05 ± 0.38	24.94 ± 0.72	24.30 ± 0.22	23.96 ± 0.74
Control group	24	20.63 ± 0.55	19.12 ± 1.17	20.16 ± 0.85	20.20 ± 0.88	20.95 ± 0.67
t		24.494	19.633	21.022	22.143	14.772
P		<0.001	<0.001	<0.001	<0.001	<0.001

4. Discussion

Residency standardized training is a crucial component of postgraduate medical education for clinical students and serves as a pivotal stage connecting theoretical learning in medical schools with independent clinical practice [5]. Chest pain, as a high-risk clinical emergency, presents with a wide variety of underlying conditions and often has subtle symptoms. Moreover, early symptoms of life-threatening chest pain diseases such as acute myocardial infarction and aortic dissection are highly similar, making misdiagnosis and missed diagnosis highly likely. This places particularly stringent demands on the specialized diagnostic and therapeutic capabilities of residency trainees. Modern medicine recognizes that traditional teaching methods, which emphasize theoretical instruction and clinical observation, have significant shortcomings in differentiating complex chest pain cases, managing sudden clinical emergencies, and implementing standardized diagnostic and therapeutic protocols. These methods often lead to rigid diagnostic thinking and non-standardized operational procedures, increasing clinical risks [6]. Therefore, optimizing specialized chest pain teaching models for residency training holds significant clinical importance in enhancing trainees' diagnostic and therapeutic capabilities for chest pain.

The PDCA cycle teaching method is a novel clinical teaching model that integrates systematic and continuous improvement, focusing on dynamic management and precise refinement throughout the entire teaching process [7]. By incorporating the four core stages of planning, execution, inspection, and handling, this model forms a complete teaching cycle that can specifically address deficiencies in chest pain simulation teaching [8]. Through precise pre-training needs assessments, it aligns with the capability gaps of residency trainees and develops individualized, specialized chest pain teaching plans, overcoming issues such as generalized content and insufficient targeting in traditional teaching. For example, scenario-based simulation exercises enable trainees to master standardized diagnostic and therapeutic protocols for high-risk chest pain, reinforcing core skills such as patient reception, physical examination, and emergency procedures, thereby steadily improving the standardization and effectiveness of specialized chest pain teaching.

In this study, the observation group significantly outperformed the control group in departmental assessment scores for theory, skill operations, and case analysis ($P < 0.05$). The reason for this is that traditional teaching primarily relies on theoretical lectures, leaving trainees with insufficient systematic simulation training. Consequently, their understanding of diagnostic and therapeutic protocols and operational essentials for high-risk chest pain diseases remains at a theoretical level, with inadequate practical proficiency. In contrast, the PDCA teaching model, through online pre-learning and offline small-group scenario-based simulations, focuses on specialized training for four life-threatening chest pain conditions. By using standardized cases and realistic simulation scenarios to replicate the entire clinical reception process, it helps trainees repeatedly engage in case evaluation and practical operations, effectively consolidating theoretical foundations and enhancing practical skills. In terms of critical thinking abilities, the observation group scored higher across all dimensions ($P < 0.05$). The reason is that PDCA teaching abandons the cramming approach of traditional methods and, through CBL, TBL group discussions, SOAP process analysis, and post-class debriefing, encourages trainees to actively think about case differentiation points and diagnostic pitfalls and to explore problem-solving strategies independently. This is highly beneficial for cultivating systematic and rigorous clinical thinking in trainees. Regarding teaching quality scores across various dimensions, the observation group also excelled ($P < 0.05$). The implementation of the PDCA teaching model optimizes the entire teaching process, ensuring targeted course content and teaching

improvement mechanisms while strengthening teacher-student collaboration. This effectively addresses issues such as outdated content, poor interactivity, and weak practical training in traditional teaching, comprehensively enhancing the overall effectiveness of residency teaching.

5. Conclusion

In summary, the PDCA cycle teaching method can strengthen the teaching effectiveness of chest pain simulation courses in residency training, improve trainees' specialized assessment scores and clinical critical thinking abilities, and optimize the overall teaching system. However, this study has certain limitations. It included only 48 residency trainees from a single hospital in the 2023 cohort, resulting in a relatively small sample size and a narrow research scope, which limits the generalizability of the findings. Additionally, the study only observed short-term teaching outcomes and did not conduct long-term follow-up on trainees' practical chest pain diagnostic and therapeutic abilities or misdiagnosis/missed diagnosis rates after graduation, making it difficult to verify the long-term application value of the teaching model. Future research could expand the sample size and conduct multi-center controlled studies involving multiple primary and tertiary hospitals to further validate the effectiveness and generalizability of the teaching model. Furthermore, a long-term follow-up mechanism should be established to track trainees' clinical practice performance, continuously refine the PDCA teaching process, and update course content in line with the latest clinical diagnostic and therapeutic guidelines, laying a solid foundation for constructing a specialized chest pain simulation teaching system for residency training that is clinically relevant and can be promoted in the long term.

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Disclosure statement

The authors declare no conflict of interest.

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