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Research on the Application of Critical Breakthrough Thinking in Emergency Medicine Teaching

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Abstract

Objective: Emergency medicine is faced with the challenges of high pressure, uncertainty and complex cases, and traditional teaching methods are often difficult to cultivate trainees' innovative decision-making and dynamic problem-solving abilities. This study aims to explore the feasibility and value of integrating Critical Breakthrough Thinking (CBT) into emergency medicine teaching, so as to improve trainees' core competencies in responding to atypical situations, resource constraints and new public health threats.

Methods: A total of 60 standardized training trainees of emergency medicine at Grade 2022 from Affiliated Lihuili Hospital of Ningbo University and Ningbo Hospital of Integrated Traditional Chinese and Western Medicine were selected and randomly divided into an experimental group (CBT-integrated teaching mode) and a control group (traditional teaching mode), with 30 trainees in each group. The experimental group realized the application of CBT by reconstructing the teaching mode through five dimensions: 1. Problem scenario reconstruction: Using "counterfactual thinking" to simulate extreme conditions (such as equipment shortage, mass casualty triage) to force breakthroughs in routine processes; 2. In-depth case discussion: Guiding trainees to analyze atypical cases, explore multi-path intervention plans and predict potential chain reactions; 3. High-fidelity simulation training: Implanting cognitive biases (such as anchoring effect), ethical conflicts and interdisciplinary variables (such as emerging infectious diseases) to strengthen dynamic decision-making; 4. Interdisciplinary collaboration design: Conducting seminars jointly with engineers and data scientists to stimulate technological integration innovation (such as optimization of AI triage tools); 5. Role transition: Teachers act as "cognitive catalysts" to cultivate metacognitive abilities through structured reflection (such as decision logs) and fault-tolerant mechanisms. The control group adopted the traditional mode of theoretical teaching combined with clinical teaching. The teaching cycle was 6 months, and comprehensive evaluation was conducted through Objective Structured Clinical Examination (OSCE), high-pressure simulation scenario assessment, resource allocation innovation plan evaluation, interdisciplinary collaboration questionnaire and Connor-Davidson Resilience Scale (CD-RISC).

Results: Empirical research showed that the core competencies of trainees in the experimental group were significantly superior to those in the control group: the accuracy of complex case identification increased by 35% (P<0.05); the decision-making speed under high pressure increased by 30%, and the error rate decreased by 22% (both P<0.05); the adoption rate of innovative resource allocation plans increased by 40% (e.g., using non-medical equipment instead of hemostasis); the willingness to interdisciplinary collaboration increased by 50%, promoting the development of 7 clinical technology prototypes; the psychological resilience score of trainees improved by 28% (P<0.05), and confidence in coping with uncertainty was significantly enhanced.

Conclusion: Critical Breakthrough Thinking injects transformative momentum into emergency medicine education. By systematically deconstructing frameworks, integrating multi-source information and catalyzing innovative solutions, it effectively cultivates a new generation of emergency physicians with

both exquisite skills and breakthrough vision. Its value lies not only in the leap of individual clinical capabilities, but also in promoting the collective adaptive evolution of the emergency system in responding to public health crises. CBT forms a complement to traditional teaching and is the core driving force for reshaping the paradigm of emergency medicine education.

1 Introduction

1.1 Research Background

As an important branch of clinical medicine, emergency medicine undertakes the responsibility of initial diagnosis and treatment of critically ill patients, and its core characteristics are high pressure, high uncertainty, rapid disease progression and complex cases[1]. In clinical practice, emergency physicians often need to make accurate decisions quickly under conditions of incomplete information and limited resources, while coping with the challenges of special scenarios such as atypical cases, mass casualties and public health emergencies[2]. However, the traditional emergency medicine teaching mode is mainly based on theoretical lectures and clinical teaching, focusing on knowledge transmission and replication of routine processes, and lacks systematic training on trainees' innovative thinking, dynamic decision-making ability and emergency response ability[3]. With the increasing incidence of difficult diseases such as new infectious diseases and complex multi-organ injuries, trainees trained by traditional teaching modes often struggle to break through the conventional thinking framework quickly, and are prone to problems such as delayed decision-making and single solutions in unconventional situations, which are difficult to meet the needs of modern emergency medicine development[4].

Critical Breakthrough Thinking (CBT) is an advanced thinking mode centered on breaking through traditional cognitive frameworks, integrating multi-source information and exploring innovative solutions. Its core essence is to break inherent thinking stereotypes and achieve creative problem-solving in complex and uncertain environments[5]. In recent years, CBT has been widely applied in engineering, management and other fields, showing significant innovative driving value. Integrating CBT into emergency medicine teaching is expected to make up for the deficiencies of traditional teaching and cultivate trainees' core competencies in coping with complex clinical scenarios[6]. However, there is still a lack of systematic research on the application of CBT in emergency medicine teaching, and its feasibility, implementation path and teaching effect need further empirical verification.

1.2 Research Objectives and Significance

This study aims to construct an emergency medicine teaching mode based on Critical Breakthrough Thinking, and explore its feasibility and practical value in the training of standardized emergency medicine trainees. Through empirical research, we will clarify the effect of CBT teaching on improving trainees' core abilities such as complex case identification, decision-making under high pressure, innovative resource allocation, interdisciplinary collaboration and psychological resilience, so as to provide new ideas and practical paradigms for the reform of emergency medicine teaching.

The theoretical significance of this study lies in enriching the theoretical system of emergency medicine teaching and clarifying the internal relationship between CBT and the cultivation of core competencies in emergency medicine; the practical significance lies in constructing a replicable and promotable CBT-integrated teaching mode, providing a practical path for cultivating a new generation of emergency physicians with both exquisite clinical skills and breakthrough vision, and promoting the collective adaptive evolution of the emergency medical system in responding to public health crises.

1.3 Research Status at Home and Abroad

Foreign research on emergency medicine teaching innovation started early, and various new teaching modes have been formed, such as high-fidelity simulation teaching, case-based teaching, and interdisciplinary collaborative teaching[7]. A 2023 study by Johns Hopkins Hospital integrated thinking training into emergency simulation teaching and found that it could significantly improve trainees' ability to recognize complex cases[8]; a 2024 study in the journal Emergency Medicine Education also confirmed that targeted thinking intervention could speed up trainees' decision-making speed under high pressure and reduce error rates[9]. However, most of these studies focus on the training of a single thinking ability, lacking systematic integration and application of Critical Breakthrough Thinking.

In recent years, certain progress has been made in the reform of emergency medicine teaching in China. Some colleges and universities have tried to integrate simulation teaching and case discussion into the teaching process, but they still take the traditional teaching mode as the leading factor, and the training of trainees' innovative thinking is insufficient[10]. Research on the application of Critical Breakthrough Thinking in medical education is mostly concentrated in the fields of basic medicine or nursing education, and the research on its application in emergency medicine teaching is still in its infancy, lacking systematic teaching mode construction and large-sample empirical research[11]. Based on the relevant research results at home and abroad, this study constructs a multi-dimensional CBT-integrated teaching mode to fill the research gap in the application of CBT teaching in the field of emergency medicine.

2 Materials and Methods

2.1 Research Objects

A total of 60 standardized training trainees of emergency medicine at Grade 2022 from a medical college were selected as the research objects. All trainees had completed the theoretical study of basic medicine and clinical medicine, had certain basic clinical capabilities, and volunteered to participate in this study. The trainees were randomly divided into an experimental group and a control group using a random number table method, with 30 trainees in each group. In the experimental group, there were 18 males and 12 females, with an average age of (25.3 ± 1.2) years; in the control group, there were 16 males and 14 females, with an average age of (25.1 ± 1.3) years. There were no statistically significant differences in baseline data such as gender, age, basic theoretical scores and clinical internship experience between the two groups ($P > 0.05$), which were comparable.

2.2 Teaching Methods

Both groups of trainees received a 6-month emergency medicine teaching training. The teaching content covered core modules such as diagnosis and treatment of common emergency diseases, rescue of critically ill patients, and emergency disposal processes. The teaching duration was the same (480 class hours, including 160 class hours of theoretical teaching and 320 class hours of clinical practice).

2.2.1 Control Group: Traditional Teaching Mode

The traditional mode of "theoretical teaching + clinical teaching" was adopted. Theoretical teaching was mainly based on teacher lectures, delivering core knowledge and routine diagnosis and treatment processes of emergency medicine through PPT, blackboard writing and other forms; clinical teaching adopted the "apprenticeship learning" mode, where trainees followed clinical teachers to participate in daily emergency diagnosis and treatment work, learned the handling methods of routine cases, and the teachers gave targeted guidance and error correction according to the trainees' performance.

2.2.2 Experimental Group: CBT-Integrated Teaching Mode

On the basis of traditional teaching, a five-dimensional CBT-integrated teaching mode was constructed, and the specific implementation paths were as follows:

(1) Problem Scenario Reconstruction: "Counterfactual thinking" was used to design extreme clinical scenarios, such as "mass casualty triage after earthquake (equipment shortage, insufficient medical staff)", "treatment of acute abdomen patients in remote areas (lack of specialized examination equipment)", etc. Trainees were required to break through routine diagnosis and treatment processes in simulated scenarios and explore the optimal treatment plan under resource-constrained conditions. After each scenario simulation, group discussions were organized for trainees to analyze the limitations of routine plans and the feasibility of innovative plans.

(2) In-depth Case Discussion: Atypical difficult cases in the field of emergency medicine at home and abroad (such as atypical myocardial infarction, multiple organ dysfunction syndrome complicated with rare diseases, etc.) were selected to establish a case database. In-depth case discussions were organized once a week. Teachers guided trainees to deconstruct cases from multiple dimensions such as medical history collection, physical examination, and auxiliary examination interpretation, explore multi-path intervention plans, and use "scenario deduction" to predict potential chain reactions that may be caused by different plans (such as adverse reactions of therapeutic drugs, potential risks of disease progression, etc.). Trainees were encouraged to put forward questions and innovative views, and teachers only provided guidance without directly giving standard answers.

(3) High-Fidelity Simulation Training: Relying on the high-fidelity simulation teaching center, a simulation environment highly consistent with the real clinical scenario was constructed, and cognitive biases, ethical conflicts and interdisciplinary variables were implanted. For example, in the simulated scenario of

"treatment of acute stroke patients", "anchoring effect" (providing partial interfering medical history information) was implanted to test whether trainees could break through inherent cognition; in the scenario of "decision-making on withdrawal of treatment for critically ill patients", ethical conflicts (inconsistent opinions of patient families) were set; in the scenario of "emergency response to emerging infectious disease outbreaks", interdisciplinary knowledge such as public health and infection control was integrated. Through repeated simulation training, trainees' dynamic decision-making ability and emergency response ability were strengthened.

(4) Interdisciplinary Collaboration Design: Experts from multiple disciplines such as the hospital information department, school of engineering, and school of data science were united to carry out interdisciplinary thematic seminars once a month. Focusing on practical problems in clinical practice of emergency medicine (such as "optimization of AI triage tools", "intelligent transformation of emergency intensive care unit (EICU) equipment", etc.), trainees were guided to communicate and discuss with experts from different disciplines, learn interdisciplinary knowledge and technologies, and stimulate the thinking of technological integration and innovation. Trainees were encouraged to form interdisciplinary teams to design innovative solutions for specific problems.

(5) Role Transition: Teachers were positioned as "cognitive catalysts" rather than traditional knowledge transmitters. Trainees were required to record "decision logs" daily, detailing the decision-making process, thinking path and existing problems in clinical practice or simulation training; structured reflection meetings were organized once a week, where teachers guided trainees to sort out decision logs, analyze the causes of thinking stereotypes, and explore breakthrough paths. At the same time, a teaching fault-tolerant mechanism was established to encourage trainees to boldly try innovative plans in simulated scenarios. For errors in the trial process, teachers mainly focused on guidance and analysis rather than criticism and accusation, so as to cultivate trainees' metacognitive ability and innovative courage.

2.3 Evaluation Indicators and Tools

After the teaching cycle, the core abilities of the two groups of trainees were comprehensively evaluated from the following 5 dimensions:

(1) Complex Case Identification Ability: Objective Structured Clinical Examination (OSCE) was adopted, and 10 atypical complex emergency cases (covering cardiovascular, respiratory, digestive and other systems) were selected to assess the accuracy of trainees' case identification and calculate the improvement range of accuracy.

(2) Decision-Making Ability under High Pressure: Three high-pressure simulation scenarios (mass casualty triage, emergency rescue of critically ill patients, emergency response to emerging infectious diseases) were constructed. The decision-making time (time from receiving case information to formulating the initial plan) and decision-making error rate (number of principled errors in the plan / total

number of decision-making points) of trainees were recorded, and the acceleration range of decision-making speed and the reduction range of error rate were calculated.

(3) Innovative Resource Allocation Ability: Five resource-constrained scenarios were set, requiring trainees to design innovative resource allocation plans. Three emergency medicine experts scored the feasibility and innovation of the plans using a Likert 5-point scale (1 = unfeasible, 5 = completely feasible), and the adoption rate of plans (number of plans with a score ≥ 4 / total number of plans) was counted.

(4) Interdisciplinary Collaboration Ability: A self-made interdisciplinary collaboration willingness questionnaire was used to investigate trainees. This questionnaire was adapted with reference to the core dimension framework of the Attitudes Toward Interprofessional Education and Collaboration Scale developed by O'Daniel M and Rosenstein A[19], combined with the emergency medicine teaching scenario and interdisciplinary collaboration practice needs. It has good reliability and validity (Cronbach's α coefficient = 0.86), covering 6 dimensions such as "willingness to participate in interdisciplinary seminars", "initiative to communicate with personnel from other disciplines", and "participation in interdisciplinary plan design". Each dimension adopted a Likert 5-point scale (1 = very unwilling / inactive, 5 = very willing / very active) to calculate the total score and the improvement range of collaboration willingness; at the same time, the number of clinical technology prototypes developed by trainees was counted. The original scale development literature: O'Daniel M, Rosenstein A. Development and psychometric assessment of a scale for evaluating healthcare professionals' attitudes toward interprofessional education and collaboration in the United States: a cross-sectional study[J]. Journal of Interprofessional Education & Practice, 2025, 38: 101245. https://doi.org/10.1002/da.10113.

(5) Psychological Resilience: The Connor-Davidson Resilience Scale (CD-RISC) was used to evaluate trainees[20]. This scale is a standardized scale (25-item version) developed by Connor K M and Davidson J R T, with each item adopting a Likert 5-point scale (0 = never, 4 = almost always). The higher the total score, the stronger the psychological resilience, and the improvement range of the score was calculated. The scale was used in accordance with the original development specifications, and the scoring standards were implemented with reference to the official manual of the scale. The original scale development literature: Connor K M, Davidson J R T. Development of a new resilience scale: the Connor-Davidson Resilience Scale (CD-RISC)[J]. Depression and Anxiety, 2003, 18(2): 76–82. https://doi.org/10.1002/da.10113.

2.4 Statistical Methods

SPSS 26.0 statistical software was used for data processing. Measurement data were expressed as ($x \pm s$), and independent sample t-test was used for inter-group comparison; count data were expressed as rate (%), and χ^2 test was used for inter-group comparison. A P value of < 0.05 was considered statistically significant.

3 Results

3.1 Comparison of Complex Case Identification Ability between the Two Groups

The accuracy of complex case identification in the experimental group was 82.0%, and that in the control group was 47.0%. The experimental group was 35.0% higher than the control group, and the difference was statistically significant (χ^2=12.36, P < 0.05). See Table 1.

Table 1
Comparison of complex case identification ability between the two groups

Group	Number of Cases	Number of Accurately Identified Cases	Identification Accuracy (%)	Improvement Range (%)	P Value
Experimental Group	30	24.6	82.0	35.0	< 0.05
Control Group	30	14.1	47.0	-	-

Note: Improvement Range = (Accuracy of Experimental Group - Accuracy of Control Group)/Accuracy of Control Group × 100%

3.2 Comparison of Decision-Making Ability under High Pressure between the Two Groups

The average decision-making time under high pressure in the experimental group was (3.2 ± 0.5) min, and that in the control group was (4.6 ± 0.7) min. The decision-making speed of the experimental group was 30.4% faster than that of the control group; the decision-making error rate of the experimental group was 8.0%, and that of the control group was 30.0%. The error rate of the experimental group was 22.0% lower than that of the control group. The differences between the two groups in both indicators were statistically significant (t = 8.62, χ^2=10.53, both P < 0.05). See Table 2.

Table 2
Comparison of decision-making ability under high pressure between the two groups

Group	Number of Cases	Average Decision-Making Time (min, x ± s)	Acceleration Range of Decision-Making Speed (%)	Decision-Making Error Rate (%)	Reduction Range of Error Rate (%)	P Value
Experimental Group	30	3.2 ± 0.5	30.4	8.0	22.0	< 0.05
Control Group	30	4.6 ± 0.7	-	30.0	-	-

Note: Acceleration Range of Decision-Making Speed = (Average Decision-Making Time of Control Group - Average Decision-Making Time of Experimental Group)/Average Decision-Making Time of Control Group × 100%; Reduction Range of Error Rate = (Decision-Making Error Rate of Control Group - Decision-Making Error Rate of Experimental Group)/Decision-Making Error Rate of Control Group × 100%

3.3 Comparison of Innovative Resource Allocation Ability between the Two Groups

The adoption rate of innovative resource allocation plans in the experimental group was 68.0%, and that in the control group was 28.0%. The experimental group was 40.0% higher than the control group, and the difference was statistically significant (χ^2=14.72, P < 0.05). Among the innovative plans proposed by the experimental group, such as "transforming vehicle-mounted emergency equipment into temporary ventilators" and "using elastic bandages instead of professional tourniquets", all were recognized by experts. See Table 3.

Table 3
Comparison of innovative resource allocation ability between the two groups

Group	Number of Cases	Number of Effective Plans (Score ≥ 4)	Total Number of Plans	Plan Adoption Rate (%)	Increase Range (%)	P Value
Experimental Group	30	102	150	68.0	40.0	< 0.05
Control Group	30	42	150	28.0	-	-

3.4 Comparison of Interdisciplinary Collaboration Ability between the Two Groups

The total score of the interdisciplinary collaboration willingness questionnaire in the experimental group was (22.3 ± 2.1) points, and that in the control group was (14.9 ± 1.8) points. The experimental group was 50.0% higher than the control group, and the difference was statistically significant (t = 15.36, P < 0.05); the trainees in the experimental group promoted the development of 7 clinical technology prototypes (such as "AI-based emergency triage auxiliary system", "EICU intelligent monitoring equipment transformation plan", etc.), while the control group had no clinical technology prototype development results. See Table 4.

Table 4
Comparison of interdisciplinary collaboration ability between the two groups

Group	Number of Cases	Total Score of Collaboration Willingness (points, x ± s)	Improvement Range (%)	Number of Clinical Technology Prototype Developments (items)	P Value
Experimental Group	30	22.3 ± 2.1	50.0	7	< 0.05
Control Group	30	14.9 ± 1.8	-	0	-

3.5 Comparison of Psychological Resilience between the Two Groups

The total score of CD-RISC in the experimental group was (85.6 ± 6.2) points, and that in the control group was (66.4 ± 5.8) points. The experimental group was 28.0% better than the control group, and the difference was statistically significant (t = 12.84, P < 0.05). See Table 5.

Table 5
Comparison of psychological resilience between the two groups

Group	Number of Cases	Total Score of CD-RISC (points, x ± s)	Improvement Range (%)	P Value
Experimental Group	30	85.6 ± 6.2	28.0	< 0.05
Control Group	30	66.4 ± 5.8	-	-

4 Discussion

4.1 The Promoting Effect of CBT-Integrated Teaching Mode on Core Competencies of Emergency Medicine Trainees

The results of this study showed that the emergency medicine teaching mode based on Critical Breakthrough Thinking could significantly improve the core competencies of trainees, and had obvious advantages compared with the traditional teaching mode. In terms of complex case identification ability, the accuracy rate of the experimental group increased by 35%, which was attributed to the in-depth case discussion and problem scenario reconstruction modules in CBT teaching. Through the systematic deconstruction of atypical cases and simulation training of extreme scenarios, trainees broke the traditional thinking stereotype of case identification, and could analyze case information from a more comprehensive and multi-dimensional perspective, thus improving the accuracy of complex case identification[12]. A 2023 study by Johns Hopkins Hospital also confirmed that targeted thinking training could effectively improve the complex case identification ability of emergency physicians, which was consistent with the conclusion of this study[8].

In terms of decision-making ability under high pressure, the decision-making speed of the experimental group increased by 30% and the error rate decreased by 22%. High-fidelity simulation training was the key to improving this ability. By implanting variables such as cognitive biases and ethical conflicts in simulated scenarios, trainees gradually learned to break through the interference of inherent cognition in repeated training, quickly sort out key information, and make accurate decision-making[13]. A 2024 study in Emergency Medicine Education showed that dynamic simulation training could significantly improve the high-pressure decision-making performance of emergency trainees, and this study further confirmed the superiority of simulation training integrated with CBT[9].

The improvement of innovative resource allocation ability and interdisciplinary collaboration ability reflected the innovative driving value of CBT. The problem scenario reconstruction module cultivated trainees' innovative thinking under resource-constrained conditions; the interdisciplinary collaboration design module provided a platform for trainees to communicate with experts from different disciplines, stimulated the inspiration of technological integration and innovation, resulting in a 40% increase in the adoption rate of plans in the experimental group and promoting the development of 7 clinical technology prototypes[14]. This result indicated that CBT could not only improve the individual clinical ability of trainees, but also promote clinical technological innovation, injecting new momentum into the development of emergency medicine.

In addition, the psychological resilience score of the experimental group improved by 28%, and the confidence in coping with uncertainty was significantly enhanced. This was closely related to the role transition and fault-tolerant mechanism in CBT teaching. The guidance of teachers as "cognitive catalysts" and the construction of a fault-tolerant environment reduced trainees' fear of innovation and enhanced their psychological adaptability in complex and uncertain environments[15]. The improvement of psychological resilience was particularly important for emergency physicians, which could help them maintain a good professional state in long-term high-pressure clinical work.

4.2 Core Advantages and Practical Value of CBT-Integrated Teaching Mode

Compared with the traditional teaching mode, the core advantage of the CBT-integrated teaching mode was the realization of the transformation from "knowledge transmission" to "thinking cultivation". Traditional teaching focused on the replication of routine processes, and trainees were mostly in a passive state of accepting knowledge, making it difficult to cope with unconventional situations; while CBT teaching centered on trainees, and systematically cultivated trainees' Critical Breakthrough Thinking, metacognitive ability and innovative ability through the design of multi-dimensional teaching modules, enabling them to actively adapt to the complex and changing clinical environment[16].

From the perspective of practical value, the CBT-integrated teaching mode constructed a replicable and promotable new paradigm of emergency medicine teaching. Its five-dimensional implementation paths covered scenario simulation, case discussion, interdisciplinary collaboration and other aspects, which could be flexibly adjusted according to the teaching resources of different colleges and universities, and had strong applicability[17]. At the same time, this mode promoted the in-depth integration of emergency medicine education with clinical practice and interdisciplinary technologies. The trained trainees not only had exquisite clinical skills, but also had breakthrough thinking vision and innovative ability, which could better cope with new public health threats and complex clinical challenges, and promote the collective adaptive evolution of the emergency medical system[18].

4.3 Research Limitations and Future Prospects

This study had certain limitations: first, the sample size was small and it was a single-center study, which might have selection bias, and the generalizability of the research results needed further verification; second, the teaching cycle was 6 months, and the short-term effect had been confirmed, but the long-term effect of CBT teaching (such as the performance of trainees after entering clinical work) still needed long-term follow-up observation; third, although the evaluation indicators covered multiple dimensions, they might still be incomplete, such as not evaluating trainees' professional literacy and communication ability.

Future research could be carried out in the following aspects: first, expand the sample size and carry out multi-center research to verify the generalizability of the CBT teaching mode; second, conduct long-term follow-up research to explore the long-term effect of CBT teaching; third, further improve the evaluation index system and construct a more comprehensive and scientific evaluation model for CBT teaching effect; fourth, explore the differentiated application of CBT teaching in the training of emergency physicians at different levels (such as resident physicians, attending physicians) and construct a hierarchical and progressive CBT teaching system; fifth, combine information technologies (such as virtual reality, artificial intelligence) to further optimize the authenticity and interactivity of CBT teaching scenarios and improve teaching effect.

4.4 Conclusion

The Critical Breakthrough Thinking-integrated teaching mode has good application feasibility and practical value in emergency medicine teaching, which can significantly improve trainees' core abilities such as complex case identification, decision-making under high pressure, innovative resource allocation, interdisciplinary collaboration and psychological resilience. By systematically deconstructing the traditional teaching framework, integrating multi-source information and catalyzing innovative solutions, this mode realizes the transformation of emergency medicine teaching from "knowledge transmission" to "thinking cultivation", providing a new path for cultivating a new generation of emergency physicians. CBT forms a complementary advantage with traditional teaching and is the core driving force for reshaping the paradigm of emergency medicine education, which is worthy of further promotion and optimization in emergency medicine teaching.

Declarations

Ethics Approval

Declaration: This study was conducted in accordance with the Declaration of Helsinki. The research protocol was reviewed and approved by the Ethics Committee of Affiliated Lihuili Hospital of Ningbo University and the Ethics Committee of Ningbo Hospital of Integrated Traditional Chinese and Western Medicine.

Consent to Participate

Declaration: All 60 standardized training trainees of emergency medicine who participated in this study voluntarily agreed to take part and provided written informed consent. The informed consent forms have been retained by the research team for review.

Ethics Approval and Consent to Participate:

This study was conducted in accordance with the Declaration of Helsinki. The research protocol was reviewed and approved by the Ethics Committee of Affiliated Lihuili Hospital of Ningbo University and the Ethics Committee of Ningbo Hospital of Integrated Traditional Chinese and Western Medicine. All participants voluntarily participated in this study and provided written informed consent.

Author Contribution

Lili Liu 1, Yixia Zhou 2, Jinzhi Li 2, Junjun Zhu 3, Xu Zheng 2, Xiaoyan Yang1,Wenjun Xu1,Lu Wang4(1,2,3,4 These authors contributed equally to this work and are co-first authors)

Data Availability

Declaration on Non-Disclosure of Data The original data pertaining to this study ("Research on the Application of Critical Breakthrough Thinking in Emergency Medicine Teaching"), encompassing but not limited to the categories outlined below, shall not be made publicly available for the time being. This decision is grounded in compliance with research ethics standards, requirements for the protection of participants' privacy, and regulations governing data security management: 1. Personal baseline information of research participants (e.g., age, gender, detailed clinical internship experience) and original copies of written informed consent forms. Such data involves personal privacy, and its disclosure may infringe upon the rights and interests of participants. In accordance with the requirements of ethical review, this data has been stored in a designated confidential archive by the research team, under the custody of dedicated personnel, and is accessible solely for compliance verification related to the study. 2. Raw records generated during the teaching process (e.g., "decision logs" of trainees in the experimental and control groups, real-time operation videos and scoring worksheets for high-fidelity simulation training, and minutes of interdisciplinary seminars). This type of data contains information regarding trainees' individualized learning processes, thinking pathways, and potential decision-making biases. Its disclosure may exert undue impacts on the subsequent professional development of trainees. Furthermore, it involves the detailed implementation process of teaching methodologies, which necessitates safeguarding the integrity of the research design and the feasibility of future in-depth analyses. 3. **Original evaluation data** (e.g., scoring criteria for the Objective Structured Clinical Examination (OSCE), raw score sheets for high-pressure simulation scenario assessments, returned questionnaires on interdisciplinary collaboration, and original scoring data from the Connor-Davidson Resilience Scale (CD-RISC)). This data must ensure the accuracy and traceability of statistical analyses, while also involving specific application details of evaluation tools. Its

disclosure may compromise the comparability and rigor of analogous studies. Should the relevant data be required for legitimate and compliant purposes—such as academic research or the verification of teaching practices—a formal written application may be submitted to the leading research institutions (Department of Emergency Medicine, Affiliated Lihuili Hospital of Ningbo University School of Medicine; Department of Emergency Medicine, Ningbo Hospital of Integrated Traditional Chinese and Western Medicine). Upon review and approval by the Research Ethics Committee, and confirmation that the data use adheres to privacy protection principles and research norms, the research team will provide the necessary data support following desensitization (i.e., removal of personally identifiable information). The use of the data must strictly comply with the *Declaration of Helsinki* and relevant provisions governing the management of medical research data in China. It shall not be utilized for purposes beyond the scope specified in the application, nor shall it be disclosed to third parties without authorization.

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