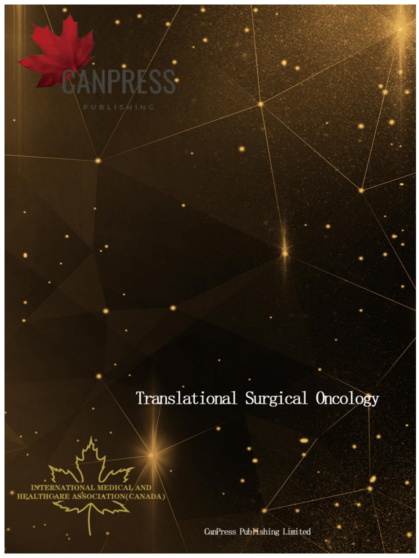

Application of a Combined PBL and CBL Teaching Model Integrated with 3D-Body Software in Clinical Teaching of Pain Medicine

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Abstract

Objective:
This study aimed to evaluate the effectiveness of a combined problem-based learning (PBL) and case-based learning (CBL) teaching model integrated with 3D-body software in the standardized residency training of anesthesiology.

Methods:
A total of 80 anesthesiology residents enrolled in the standardized residency program at the First Affiliated Hospital of Kunming Medical University from 2021 to 2023 were randomly assigned to either the experimental group or the control group, with 40 residents in each group. The experimental group received teaching based on the PBL+CBL integrated model together with 3D-body software, while the control group was taught using conventional methods. The effectiveness of the two teaching approaches was assessed and compared using surveys related to teaching satisfaction, as well as scores from departmental theoretical and clinical skills examinations.

Results:
There were no statistically significant differences in baseline data such as age, gender, and admission examination scores between the two groups ($P > 0.05$). In the assessments at the end of the rotation, the experimental group achieved significantly higher scores in both theoretical knowledge and clinical skills examinations compared to the control group ($P < 0.05$). Questionnaire results revealed that residents in the experimental group outperformed those in the control group in clinical skills, self-confidence, teamwork, and satisfaction with clinical teaching, with statistically significant differences ($P < 0.05$).

Conclusion:
The PBL+CBL hybrid teaching model, when combined with 3D-body software, can significantly enhance anesthesiology residents' learning enthusiasm and initiative, improve their ability to integrate and comprehend knowledge, and better cultivate their competence in analyzing and solving clinical problems. This approach provides an effective reference for resident education in anesthesiology.

Keywords: PBL, CBL, 3D-body software, teaching methods, clinical instruction, effectiveness

Copyright and usage

Introduction

With the continuous advancement of modern medicine, medical education has also been experiencing rapid evolution and reform. As a pivotal field within contemporary medicine, anesthesiology requires advanced educational concepts and models to establish a solid foundation for training professionals in pain medicine[1]. The experimental implementation of the "Global Minimum Essential Requirements in Medical Education (GMER)" emphasizes that modern medical students must not only master theoretical knowledge but also prioritize the development of clinical thinking and skills[2]. Pain medicine, as a core component and critical subspecialty of anesthesiology, is highly specialized and intersects extensively with other areas such as surgery, internal medicine, psychiatry, gynecology, and dermatology[3]. This integration results in a complex and intricate learning process. Compared to other clinical specialties, pain-related clinical operations are also more demanding, requiring trainees to have a detailed understanding of the anatomical relationships among skin, muscles, bones, blood vessels, and nerves[4]. Given the limited duration of standardized residency training, ensuring that trainees can comprehensively master and proficiently apply essential concepts, principles, and skills in pain management remains a central challenge in clinical education.

In traditional teaching models, residency training in pain medicine is often instructor-centered, especially regarding clinical skills training, which mainly relies on live demonstrations and step-by-step explanations by the instructor [5-6]. Although current teaching models may incorporate questioning, case analysis, and digital resources, most residents still have difficulty translating theoretical knowledge into clinical skills, and the cultivation of practical hands-on ability is often neglected[7]. Deficiencies persist in developing clinical reasoning and problem-solving skills. Enhancing the technical competence and practical problem-solving abilities of anesthesiology residents has thus become a pressing challenge in medical education. To improve residents' clinical skills and cultivate clinical thinking, our department has sought to integrate the advantages of traditional teaching approaches with a blended PBL+CBL model supported by 3D-body software. The aim is to leverage this educational strategy to enhance students' clinical skills and foster their development of clinical reasoning.

1 Materials and Methods

1.1 Study Participants

A total of 80 residents from the standardized anesthesiology residency training program at the First Affiliated Hospital of Kunming Medical University between 2021 and 2023 were selected for this study. The participants were randomly assigned into two groups: the observation group (n = 40) and the control group (n = 40). There were no statistically significant differences between the two groups in terms of baseline characteristics, including gender, age, and admission scores ($P > 0.05$). Furthermore, each cohort within the observation group was subdivided into five smaller teams comprising 8 residents each.

1.2 Teaching Methods

1.2.1 Preparatory Phase

Prior to the commencement of formal instruction, a presentation introducing the combined PBL+CBL teaching model and the use of 3D-body software was conducted for newly enrolled students. This session aimed to ensure thorough understanding of the methodology and learning objectives, as well as to stimulate participants' engagement and enthusiasm for the teaching model.

1.2.2 Implementation

(1) Case Selection:

Representative cases were selected based on common pain conditions encountered in the department, including cervical spondylosis, postherpetic neuralgia, lumbar disc herniation, knee pain, and cancer pain. These cases with embedded clinical problems were used as the foundation for the blended PBL+CBL educational model, integrated with the 3D-body anatomy software.

(2) Control Group:

Conventional education strategies were utilized for the control group. After the new residents joined the department, clinical instructors delivered instruction using multimedia courseware and other teaching tools, following the requirements of standardized residency training. The curriculum covered pain management content from "Surgery" and "Pain Medicine." Instructors provided lectures, discussions, and demonstrations on common clinical problems and skills, followed by simulated practice, and subsequently supervised real clinical procedures. Teaching rounds were held biweekly, and small-group lectures were organized regularly. Visual aids such as atlases and imaging data, together with multimedia tools, were employed to explain clinical manifestations, diagnostic processes, medication selection and type of analgesics, options and protocols for minimally invasive treatments, complication management, and in-hospital pain management strategies.

(3) Observation Group:

The clinical education for the observation group was conducted using a blended PBL+CBL model combined with 3D-body software, consistent with the training curriculum. Each group of 8 residents was assigned a team leader and a recorder to facilitate organization and documentation. Every member was responsible for managing a patient with a common pain disorder. The small-group learning format encouraged active discussion and problem-posing among members. For each clinical question identified, students were tasked with independently gathering information via educational materials, online resources, and library references, and collaboratively designing individualized treatment plans based on actual cases. Before engaging in invasive pain management techniques, the instructor used 3D-body software to demonstrate key principles, puncture sites, approaches, and targets. During real-life procedures, the instructor provided detailed step-by-step explanations, while students utilized the software to observe and understand the process along with adjacent anatomical structures. All instructional activities and procedures were conducted under faculty supervision, ensuring effective guidance and support through active facilitation. Upon completion of noninvasive or minimally invasive interventions, the instructor again utilized the 3D-body software for case reviews and to reinforce mastery of the procedures.

1.3 Evaluation

Upon completion of training, teaching effectiveness was evaluated for both groups using a combination of questionnaire surveys and departmental examination scores. Assessments included a written theoretical examination, case analysis, and clinical skills assessment. The survey evaluated trainees' perceptions of their clinical skills, self-confidence, teamwork, and their satisfaction with clinical instruction.

1.4 Statistical Analysis

All data were analyzed using SPSS 20.0 software. Categorical variables were analyzed using the chi-square ($\chi 2$) test, and continuous data were analyzed using the t-test (mean ± standard deviation). A *P*-value < 0.05 was considered statistically significant.

2 Results

2.1 Effectiveness of Classroom Teaching

A comparative analysis of the teaching dynamics revealed that the PBL+CBL blended teaching model integrated with 3D-body anatomy software significantly enhanced students' classroom enthusiasm. Trainees in the observation group demonstrated more active participation and engagement, leading to a more dynamic and interactive classroom atmosphere. In contrast, the control group—taught using traditional methods—experienced limited interaction between instructors and students, resulting in a comparatively monotonous environment and lower levels of learning motivation. Furthermore, residents in the control group reported lower learning efficiency and a lack of lasting impressions regarding the material covered.

2.2 Analysis of Final Examination Performance

In the end-of-department examinations, the mean score of the observation group was 84.67 ± 7.53, which was significantly higher than the control group's average of 72.69 ± 6.75. The case analysis component accounted for 30% of the total exam score, with a maximum of 30 points, and was designed to evaluate students' abilities to apply learned knowledge to problem-solving. Analysis of the scores demonstrated that the observation group achieved a substantially higher average on case analysis questions (24.23 ± 0.73) compared to the control group (17.06 ± 1.08). In the clinical skills assessment, the observation group also scored markedly higher (85.34 ± 6.32) than the control group (64.21 ± 5.56). Detailed results are presented in Table 1.

2.3 Results of Questionnaire Survey

Analysis of the post-course questionnaire indicated that the PBL+CBL blended teaching model combined with 3D-body anatomy software effectively stimulated the classroom environment and enhanced students' enthusiasm for learning. This educational approach had positive effects on residents' self-perceived clinical skills, self-confidence, teamwork abilities, and satisfaction with clinical instruction. Detailed results are presented in Table 2.

3 Discussion

PBL method is a student-centered approach that centers on clinical problems and fosters extended and in-depth thinking through teamwork and discussion[8]. The continued implementation of PBL facilitates students' ability to review and integrate acquired knowledge, as well as to conduct independent research during their spare time. Moreover, PBL enhances independent learning skills, oral communication and interpersonal skills, teamwork, and critical thinking abilities[9-10].

CBL) is a discussion-oriented educational model centered on real clinical cases, designed to guide students in thinking, analyzing, and discussing, thereby improving their problem-solving abilities[11]. CBL primarily emphasizes the development of clinical reasoning—including diagnosis, differential diagnosis, treatment planning, and decision-making—supported by related knowledge such as fundamental concepts, principles, methods, and evidence-based medicine. Through interactive activities, CBL helps students establish clinical thinking patterns and notably enhances their ability to resolve real-world clinical issues[12].

The 3D-body digital anatomy software is based on authentic CT and MRI data and can be accessed through a free mobile application. This software provides high-resolution, interactive three-dimensional anatomical models of human systems and organs, vividly displaying the structure and spatial relationships of each organ and tissue, thereby overcoming the limitations of traditional two-dimensional anatomy. It not only facilitates students' understanding of the relative positions of target organs, but also helps improve their independent learning and hands-on skills.

Traditional residency training in China is largely lecture-based [13], often utilizing the so-called "cramming method" of teaching. Although instructors follow detailed plans for theory and technical procedures, students tend to be passive recipients with limited engagement, resulting in suboptimal learning outcomes[14]. In this model, the teacher is the dominant figure, making it difficult for residents to develop self-awareness or to improve their ability to recognize and address clinical problems independently[15]. In contrast, the blended PBL+CBL teaching model combined with 3D-body anatomy software integrates the strengths of both approaches, establishing a student-centered environment in which clinical questions and cases are the focus. The visual and interactive power of the 3D-body software further enhances engagement and interest. Throughout the teaching process, students are encouraged to independently research and reflect on clinical problems, while teachers serve primarily as facilitators, evaluators, and providers of supplementary information and corrections. The fusion of PBL and CBL, supported by the 3D-body platform, can greatly inspire students' self-directed learning, strengthen their reasoning and problem-solving skills, and prepare them to apply their knowledge directly in practical clinical settings, thereby contributing to the development of outstanding medical professionals.

In summary, the combination of PBL+CBL blended learning with the 3D-body tool not only guides students through challenging cases but also visually presents pain medicine knowledge, motivating students to engage in deeper study, inquiry, and research. This strategy also helps to improve the ability to transform two-dimensional images into three-dimensional conceptualizations, greatly synergizing with bedside teaching and effectively integrating theoretical knowledge with practical adaptability. It significantly enhances students' clinical problem-solving skills and cultivates their clinical reasoning abilities. Therefore, this model is highly suitable for widespread application in clinical education.

Table 1. Comparison of Final Examination Results Between Two Groups

Group	n	Average Exam Score	Case Analysis	Skills Assessment
Observation	40	84.67±7.53	24.23±0.73	85.34±6.32
Control	40	72.69±6.75	17.06±1.08	64.21±5.56
t-value		3.865	8.265	4.563
P-value		＜0.01	＜0.01	＜0.01

Table 2. Statistical Analysis of Questionnaire Survey Between Two Teaching Methods

Group	n	Teaching Satisfaction (n/%)	Clinical Skills (n/%)	Self-confidence (n/%)	Teamwork Ability (n/%)
Observation	40	37（92.5%）	36（90.0%）	38（95.0%）	35（87.5%）
Control	40	26（65.0%）	25（62.5%）	20（50.0%）	21（52.5%）
t-value		6.94	8.66	36.52	16.54
P-value		＜0.01	＜0.01	＜0.01	＜0.01

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Competing interests

The authors declare that they have no competing interests.

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