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2025 Volume 10, Issue 4
Advances in Precision Medicine
ISSN: 2424-9106 (Online)
ISSN: 2424-8592 (Print)

Practice and Effects of Case-Oriented Blended Learning in the Teaching of Perioperative Fluid Management for Nurse Anesthetists

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Abstract: *Objective:* To investigate the application effect of case-oriented blended teaching in perioperative fluid management education for anesthesia nurses, and to provide practical evidence for improving the core professional competencies of anesthesia nurses. *Methods:* Eighty anesthesia nurses who rotated through the Department of Anesthesiology of our hospital from January to December, 2023 were selected as the research subjects and randomly divided into a control group (n = 40) and an observation group (n = 40) using a random number table. The control group received traditional lecture-based teaching, while the observation group received case-oriented blended teaching. The theoretical assessment scores, practical examination scores, clinical decision-making ability ratings, and teaching satisfaction were compared between the two groups after the instruction. Results: The theoretical examination scores (89.65 ± 5.32) and practical examination scores (91.23 ± 4.18) in the observation group were significantly higher than those in the control group (78.34 ± 6.75) and (80.56 ± 5.89) respectively, with statistically significant differences ($p < 0.05$). The scores and total score of all dimensions of clinical decision-making ability in the observation group were higher than those in the control group. Among them, the scores of problem identification (18.76 ± 2.13) points *vs*. (14.32 ± 2.56), plan formulation (17.89 ± 1.98) *vs*. (13.15 ± 2.34), implementation evaluation (19.02 ± 2.05) *vs*. (14.56 ± 2.47), and total score (55.67 ± 5.23) *vs*. (42.03 ± 6.18) were all statistically significant ($p < 0.05$). The teaching satisfaction rate of the observation group was 97.50% (39/40), which was significantly higher than that of the control group (77.50%, 31/40), and the difference was statistically significant ($p < 0.05$). *Conclusion:* Case-oriented blended teaching can effectively enhance the theoretical knowledge, operational skills, and clinical decision-making ability of anesthesia nurses in perioperative fluid management, as well as improve teaching satisfaction. It is worthy of promotion and application in clinical teaching.

Keywords: Case-oriented teaching; Blended teaching; Anesthesia nurses; Perioperative fluid management; Teaching effectiveness

Online publication: December 20, 2025

1. Introduction

Perioperative fluid management is a core component of anesthesia nursing care, directly influencing patients' surgical safety, postoperative recovery, and prognosis [1]. As crucial participants in perioperative patient care, anesthesia nurses

must possess solid theoretical knowledge of fluid management, proficient operational skills, and accurate clinical decision-making abilities to address complex issues such as intraoperative circulatory fluctuations and volume assessment [2]. However, traditional lecture-based teaching, centered on the instructor, emphasizes the impartation of theoretical knowledge, lacks integration with clinical cases and interactive practice. This makes it difficult for nurses to translate theoretical knowledge into clinical application skills, resulting in suboptimal teaching effectiveness [3]. Case-oriented teaching utilizes authentic clinical cases as a vehicle to stimulate learners' active thinking and cultivate their clinical thinking ability through question guidance, group discussions and other methods [4]. Blended teaching, on the other hand, combines the flexibility of online teaching with the interactivity of offline teaching, achieving an organic integration of "online self-study + in-depth offline discussion" [5]. This study combines case-oriented teaching with the blended teaching model and applies it to perioperative fluid management instruction for anesthesia nurses. The aim is to optimize the teaching program, enhance teaching quality, and provide a new pathway for cultivating the core competencies of anesthesia nurses.

2. Materials and methods

2.1. Study subjects

Eighty anesthesia nurses who rotated through the Department of Anesthesiology in our hospital from January 2023 to December 2023 were selected as the study subjects.

2.1.1. Inclusion criteria

(1) Hold a valid registered nurse (RN) license and have 1 to 3 years of experience in anesthesia care.;
(2) Voluntarily participate in this study and sign an informed consent form.
(3) Have no serious illnesses or special circumstances and be able to complete the entire teaching and assessment process.

2.1.2. Exclusion criteria

(1) Those who are unable to participate in the full teaching during the rotation period due to job transfer, sick leave, etc.
(2) Those who have previously received systematic perioperative fluid management training.

2.1.3. Study design

The study subjects were randomly divided into a control group (n = 40) and an observation group (n = 40) using a random number table. There were no statistically significant differences in general characteristics such as gender, age, years of work experience, and initial educational level between the two groups ($p > 0.05$), indicating comparability. See **Table 1** for details.

Table 1. Baseline characteristics of the anesthesia nurse groups

Indicator	Control group (n = 40)	Observation group (n = 40)	Statistical value (t/χ^2)	p-value
Gender, n (%)	35 / 5	33 / 7	0.41	0.52
Age (years), Mean ± SD	25.67 ± 2.34	26.12 ± 2.18	0.92	0.36
Working Years (years), Mean ± SD	2.13 ± 0.85	2.25 ± 0.79	0.63	0.53
Highest Education Level, n(%)	28 (70.00)	30 (75.00)	0.38	0.54

2.2. Teaching methods

The teaching content of both groups revolves around perioperative fluid management, including:

(1) Theoretical knowledge

Perioperative fluid physiology, volume assessment indicators (such as heart rate, blood pressure, central venous pressure, urine output, etc.), fluid selection (crystalloid solutions, colloidal solutions, blood products), fluid management strategies for different types of surgeries (abdominal surgery, cardiovascular surgery, neurosurgery), and prevention and treatment of complications (such as volume overload, hypovolemic shock).

(2) Practical skills

Establishment of intravenous access (peripheral vein and central vein puncture), adjustment of fluid infusion rate, and use of capacity monitoring equipment (such as non-invasive hemodynamic monitoring device). The teaching cycle is 4 weeks, with 8 class hours per week, for a total of 32 class hours.

2.2.1. Control group

The traditional model of "teacher instruction + video demonstration" was adopted:

(1) Offline classroom instruction

The teacher explained the theoretical knowledge of perioperative fluid management through Microsoft PowerPoint (PPT) and demonstrated the operation of intravenous puncture and volume monitoring in combination with teaching video.

(2) After-class assignments

Theoretical exercises and operation procedures were assigned. The nurses completed the assignments independently and submitted paper assignments. The teacher corrected and provided feedback.

(3) Pre-examination review

After the completion of teaching, the teacher summarized the key knowledge and addressed nurses' questions.

2.2.2. Observation group

A three-stage teaching model of "online self-study learning–offline case discussion–clinical practice reinforcement" was constructed, implemented as follows:

(1) Online self-study phase (1 week, 16 class hours)

An online teaching platform (using the "Cloud Classroom" system of our hospital's nursing department) was established, and teaching resources were uploaded: (A) Theoretical micro-lectures: The knowledge of perioperative fluid management was broken down into 6thematic micro-lectures (15–20 minutes each), including "Interpretation of Volume Assessment Indicators" and "Selection of Colloid fluids *vs*. Crystalloid fluids", with accompanying knowledge point quizzes (1 point per question, 100 points in total, 80 points or above were required to proceed to the next stage). (B) Case Material Library: Ten real clinical cases (de-identified) were uploaded, covering various surgical types (such as "Fluid Management of Intraoperative Hypotension in Patients undergoing Laparoscopic Cholecystectomy" and "Correction of Hypertonic Dehydration in Patients undergoing Craniotomy"). Each case included basic patient information, preoperative assessment, intraoperative monitoring data, fluid therapy regimen, and prognosis. (C) Extended Resources: Recommendations were provided for domestic and international guidelines on perioperative fluid management (such as the ASA guidelines), expert consensus, and literature reviews for nurses to consult independently. Nurses were required to complete online learning within one week, with the platform automatically recording learning time and test scores. Teachers monitored learning progress in real-time through the platform and provided one-on-one guidance to those who had not met the standards.

(2) Offline case discussion phase (2 weeks, 16 class hours)

(A) Group discussion (Week 1, 8 hours): Divide 40 nurses into 8 groups (5 nurses per group), and assign each

group a case from an online case database. Set discussion questions (such as "What are the criteria for determining intraoperative volume in this patient?" "Why choose hydroxyethyl starch instead of albumin?"). Each group first had 1-hour of independent discussion to organize their thoughts. Subsequently, one representative from each group was given a 15-minute case presentation. The instructor asked questions based on the presentation (such as "If the patient develops pulmonary edema, how should the fluid therapy plan be adjusted?") to guide the groups to supplement the discussion. Finally, the instructor summarized the core knowledge points and clinical decision-making logic within the case. (B) Simulated practical training (Week 2, 8 hours): Conduct operational exercises in the anesthesiology simulation training room, utilizing a high-fidelity simulator (model: Laerdal SimMan 3G) to replicate clinical scenarios, such as "The patient's heart rate increases and blood pressure decreases during surgery, with monitoring showing Central Venous Pressure (CVP) of 5 cmH_2O and urine output of 20 mL/h". Nurses are required to: a. rapidly assess the patient's volume status; b. select an appropriate intravenous access (peripheral/central vein) and complete the puncture; c. develop a fluid infusion plan (type, rate); d. monitor the therapeutic effects and adjust the plan accordingly. Teachers provide on-site guidance and promptly correct operational errors (such as improper central venous puncture angle or incorrect calculations of fluid infusion rate). Each nurse must complete three simulated operations in different scenarios, and only those who pass the operation (with a teacher's score of 80 or above) can enter the clinical practice stage.

(3) Clinical Practice Intensification Phase (1 week, 8 hours).

Nurses are arranged to enter the anesthesiology operating rooms to participate in the perioperative fluid management of real patients, with one-on-one guidance from supervising teachers (who have more than 5 years of teaching experience in anesthesia nursing education). (A) Preoperatively: Assist the supervising teacher in conducting patient volume assessment, record assessment indicators, and propose preliminary fluid therapy recommendations. (B) Intraoperatively: Observe the patient's vital signs and monitoring data, adjust the fluid infusion rate according to the supervising teacher's guidance, and record the fluid intake and output. (C) Postoperatively: Participate in the evaluation of the effectiveness of the patient's postoperative fluid management, and summarize the experiences and shortcomings of this practice. After each day's practice, nurses submit a practice log (documenting case details, operational content, issues encountered, and reflections). The supervising teacher reviews the logs and provides 15 minutes of one-on-one feedback to enhance teaching effectiveness.

2.3. Observation indicators

2.3.1. Teaching assessment scores

After the teaching session, nurses from both groups participated in the assessment simultaneously, with assessment content and criteria being the same.

(1) Theoretical assessment

A closed-book examination was conducted, featuring multiple-choice questions (50 points), short-answer questions (30 points), and case analysis questions (20 points), with a total of 100 points. The assessment time is 90 minutes.

(2) Practical assessment

Conducted in a simulation training room. The assessment project was "Central Venous Catheterization + Liquid Infusion Plan Formulation". The assessment criteria included operational standardization (40 points), plan rationality (30 points), and emergency response (30 points). The average score was taken as the final practical assessment score, with a total of 100 points.

2.3.2. Clinical decision-making ability score

The Clinical Decision-Making Inventory (CDMI) was used for evaluation. This inventory comprises three dimensions: problem identification (6 items), plan formulation (5 items), and execution assessment (6 items), totaling 17 items. Each

item is scored from 1 to 4 (1 point = "completely inconsistent", 4 points = "completely consistent"). The total score ranges from 17 to 68 points, with higher scores indicating stronger clinical decision-making abilities [6].

2.3.3 Teaching satisfaction

The self-designed "Teaching Satisfaction Questionnaire" was employed, categorizing satisfaction into three levels: satisfied (40–50 points), basically satisfied (30–39 points), and dissatisfied (< 30 points). The satisfaction level was calculated as (Number of satisfied cases + Number of basically satisfied cases) / Total number of cases × 100%.

2.4. Statistical methods

Data analysis was conducted using SPSS 27.0 statistical software. Quantitative data were expressed as mean ± standard deviation (SD), and comparisons between groups were made using the independent samples *t*-test. Categorical data were expressed as (*n,%*), and comparisons between groups were made using the χ^2 test. A p-value < 0.05 was considered statistically significant.

3. Results

3.1. Comparison of teaching assessment scores between the two groups of nurses

The theoretical assessment scores and practical assessment scores of the observation group were significantly higher than those of the control group, with statistically significant differences ($p < 0.05$), as detailed in **Table 2**.

Table 2. Comparison of teaching assessment scores between the two groups of anesthesia nurses

Assessment type	Control group (n = 40)	Observation group (n = 40)	t-value	p-value
Theoretical score	78.34 ± 6.75	89.65 ± 5.32	8.76	< 0.05
Practical score	80.56 ± 5.89	91.23 ± 4.18	9.21	< 0.05

3.2. Comparison of clinical decision-making ability scores between two groups of nurses

The scores for each dimension of clinical decision-making ability and the total score in the observation group were significantly higher than those in the control group, and the differences were statistically significant ($p < 0.05$), as detailed in **Table 3**.

Table 3. Comparison of clinical decision-making ability scores between the two groups of anesthesia nurses

Assessment type	Control group (n = 40)	Observation group (n = 40)	t-value	p-value
Problem recognition	14.32 ± 2.56	18.76 ± 2.13	8.34	< 0.05
Plan formulation	13.15 ± 2.34	17.89 ± 1.98	9.01	< 0.05
Execution & evaluation	14.56 ± 2.47	19.02 ± 2.05	8.87	< 0.05
Total score	42.03 ± 6.18	55.67 ± 5.23	9.56	< 0.05

3.3. Comparison of teaching satisfaction between two groups of nurses

The teaching satisfaction rate in the observation group was 97.50%, which was significantly higher than that in the control group (77.50%). The difference was statistically significant ($p < 0.05$). See **Table 4** for details.

Table 4. Comparison of teaching satisfaction between two groups of anesthesia nurses

Satisfaction level	Control group (n = 40)	Observation group (n = 40)	χ^2 value	p-value
Satisfied	18 (45.00)	32 (80.00)	7.31	< 0.05
Basically Satisfied	13 (32.50)	7 (17.50)		
Dissatisfied	9 (22.50)	1 (2.50)		
Total Satisfaction	31 (77.50)	39 (97.50)		

4. Discussion

In traditional lecture-based teaching, nurses passively receive knowledge, find it difficult to understand abstract concepts (such as "the time-dependency of the volume expansion effect of colloidal solutions"), and lack opportunities for hands-on practice, leading to a disconnection between theory and practice [7]. In contrast, case-oriented blended learning breaks down complex knowledge into fragmented content through online micro-lectures, making it easier for nurses to learn independently during fragmented time. Accompanying knowledge point tests can strengthen knowledge memory. Offline simulated practical training, combined with high-fidelity simulation mannequins to restore clinical scenarios, allowing nurses to familiarize themselves with operational procedures in a "real-combat". Real-time guidance of instructors can promptly correct errors and enhance operational standardization [8]. In addition, the clinical practice phase involves nurses in the care of real patients, applying theoretical knowledge and practical skills to real-world scenarios, further consolidating the teaching effect. The results of this study showed that the observation group's theoretical assessment scores (89.65 ± 5.32) and operational assessment (91.23 ± 4.18) were significantly higher than the control group ($p < 0.05$), indicating that case-oriented blended teaching can effectively enhance the theoretical and operational capabilities of anesthesia nurses in perioperative fluid management.

Clinical decision-making ability is the core competency of anesthesia nurses to cope with complex perioperative situations and requires gradually cultivated through long-term practice and reflection [9]. In this study, the total score of clinical decision-making ability in the observation group (55.67 ± 5.23) was significantly higher than that in the control group (42.03 ± 6.18) ($p < 0.05$), especially in the dimensions of problem identification and plan formulation. This is closely related to the advantages of case-oriented teaching. The online case database provides real-world cases covering various clinical scenarios, allowing nurses to be exposed to complex cases in advance. Offline group discussions, guided by questions, stimulate nurses to actively think about "how to identify volume issues from monitoring data" and "the differences in applicable scenarios for different fluid regimens", gradually establishing a clinical thinking logic of "assessment-analysis-decision" [10]. For example, in the case discussion of "hyperosmotic dehydration in patients undergoing craniocerebral surgery", nurses are required to comprehensively assess the patient's volume status by considering preoperative serum sodium levels (155 mmol/L), intraoperative urine output (30 mL/h), and CVP (8 cmH_2O), rather than relying solely on a single indicator. This case-based multidimensional analysis training effectively enhances problem identification skills.

Simulated practical training employs a closed-loop model of "scenario simulation, decision implementation, the effect feedback" to strengthen skills in plan formulation and execution evaluation. When the simulator exhibits symptoms such as "heart rate increasing to 120 beats per minute and blood pressure dropping to 85/50 mmHg", nurses must promptly select the type of venous access (such as central venous puncture to ensure rapid fluid resuscitation), calculate the fluid infusion rate (such as rapid infusion of crystalloid solution at 10 mL/kg), and observe changes in heart rate and blood pressure after infusion to evaluate the effects. During training, teachers use "inquiry-based guidance" (such as "What other factors should be considered if blood pressure does not recover after infusion?") to prompt nurses to reflect on deficiencies in their decision-making and gradually optimize the clinical decision-making process. Participation in real cases during the

clinical practice phase further translates decision-making experience from simulated scenarios into practical application skills, forming a progressive chain of ability development from “theory—simulation—practice”.

The teaching satisfaction in the observation group (97.50%) was significantly higher than that in the control group (77.50%) ($p < 0.05$), which was closely related to the “nurse-centered” philosophy of the blended teaching model. In traditional lecture-based teaching, nurses were in a passive learning position, lacking a sense of participation and interactivity, and were prone to learning fatigue. In contrast, the case-oriented blended teaching approach empowered nurses with learning autonomy through online self-directed learning, enabling them to adjust their learning pace according to their own rhythm (such as repeatedly watching the difficult content on “central venous puncture positioning” in the micro-lectures). Offline group discussions and simulated practical sessions created an interactive and collaborative learning atmosphere, where nurses shared viewpoints and inspired each other during group exchanges, enhancing their learning enthusiasm. Additionally, one-on-one feedback in clinical practice made nurses feel personalized attention, boosting their sense of learning achievement. In this study, only one nurse in the observation group expressed dissatisfaction with the teaching, primarily due to “conflicts between online learning time and work”, suggesting the need for further optimization of online learning schedules (such as adding nighttime learning sessions) to enhance teaching flexibility.

This study has the following limitations:

(1) The sample size is small and sourced from a single hospital, which may lead to selection bias. The generalizability of the results requires validation through multi-center, large-sample studies.

(2) The teaching effectiveness was only followed up until the end of the teaching period, without long-term follow-up (such as after 6 months), making it impossible to evaluate the impact of this teaching model on nurses’ long-term clinical competence.

(3) The differences in ability improvement among nurses with varying years of work experience were not analyzed, making it impossible to determine the differences in applicability of this teaching model between novice and experienced nurses.

In summary, the case-oriented blended teaching model, through its three-stage approach of “online self-learning–offline case discussion–clinical practice reinforcement”, breaks the limitations of traditional teaching. It can effectively enhance the theoretical knowledge, operational skills, and clinical decision-making abilities of anesthesia nurses in perioperative fluid management, significantly improving teaching satisfaction. This teaching model aligns with the clinical needs of anesthesia nursing, providing a feasible pathway for cultivating the core competencies of anesthesia nurses. It is worthy of promotion and application in clinical teaching and can be further optimized and improved based on actual conditions.

Funding

1. Shaanxi Provincial People’s Hospital, Construction and Application of a PACU Infusion Safety Management Scheme Based on the FMEA Model (Project No.: 2023HL-41);
2. Shaanxi Provincial People's Hospital: Mechanism study of HSP90-regulated DRP1 acetylation leading to endothelial cell mitochondrial dynamics imbalance promoting atherosclerosis progression(Project No.: 2025JC-YBQN-1163) ;
3. Mechanism study of atorvastatin exerting direct vascular endothelial protective effects(Project No.: 2023YJY-28).

Disclosure statement

The authors declare no conflict of interest.

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