Application of Multidisciplinary Collaborative Teaching Based on Integrative Medicine in Thoracic Tumor Surgery Education

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AIM: To evaluate the effectiveness of a multidisciplinary collaborative teaching model based on integrative medicine in thoracic tumor surgery education.

METHODS: This single-center retrospective study included sixty-one clinical interns who underwent training in the Department of Thoracic Disease Diagnosis and Treatment Center at The Third Affiliated Hospital of Jiaxing University (Zhejiang Rongjun Hospital) from March 2022 to March 2025. Based on the implementation period of the teaching model, participants were assigned to a control group (n = 30) or an observation group (n = 31). The control group received traditional teaching, whereas the observation group received multidisciplinary collaborative teaching based on integrative medicine, including multidisciplinary team (MDT) case discussions, scenario-based simulation, and simulated surgical skills training. Both groups underwent 3 months of training. After training, the theoretical knowledge assessment scores, comprehensive clinical competence (Mini-Clinical Evaluation Exercise (Mini-CEX) assessment, including dimensions such as medical history taking and case analysis, clinical reasoning and judgment, doctor-patient communication, and Organization/Efficiency), operational skills (operational standardization, teamwork, instrument proficiency, and mastery of basic surgical skills), and teaching satisfaction were compared between the two groups.

RESULTS: After training, the observation group achieved significantly higher theoretical knowledge scores than the control group ($p < 0.05$). For comprehensive clinical skills, the observation group scored significantly higher in history taking and case analysis, clinical reasoning and judgment, and Organization/Efficiency ($p < 0.05$), whereas no significant difference was observed in doctor-patient communication ($p = 0.402$). Regarding operational skills, the observation group performed significantly better in operational standardization, teamwork, and instrument proficiency (all $p < 0.05$), while basic skills mastery did not differ significantly between groups ($p = 0.262$). Teaching satisfaction scores for teaching methods, teaching content, learning enthusiasm, and overall satisfaction were significantly higher in the observation group (all $p < 0.05$), whereas no significant differences were found in effectiveness or practicality (all $p > 0.05$).

CONCLUSIONS: Multidisciplinary collaborative teaching based on integrative medicine was associated with improved theoretical knowledge, selected aspects of clinical competence (history taking and case analysis, clinical reasoning and judgment, Organization/Efficiency), certain operational skills (operation standardization, teamwork, and instrument proficiency), and higher teaching satisfaction. However, improvements were not observed across all competency domains. This teaching model may have value in standardized thoracic oncology training, although prospective studies are needed for further validation.

Keywords: integrative medicine; multidisciplinary collaborative teaching; clinical internship; surgical education

Introduction

Thoracic tumors are a major group of diseases that pose a serious threat to human health. With the widespread use of low-dose spiral computed tomography (CT) screening, improvements in perioperative management, and advances in minimally invasive techniques, the surgical treatment of thoracic tumors has gradually entered an era of precision, minimally invasive, and comprehensive treatment [1]. At present, video-assisted thoracoscopic surgery (VATS) and robot-assisted surgery are widely used in clinical practice, significantly reducing surgical trauma and perioperative complications while improving oncological outcomes [2,3]. However, thoracic tumor surgery involves complex anatomical structures, strict adherence to tumor-free principles, and multidisciplinary management throughout the perioperative period, placing higher demands on clinicians' theoretical knowledge, technical skills and comprehensive decision-making abilities [4]. Therefore, developing a scientific and efficient surgical teaching model that aligns with

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modern medical advances has become an important issue in the standardized training of thoracic surgery clinical interns.

Traditional surgical teaching models mainly rely on the transmission of mentors' experience and the teaching of discipline-specific knowledge. The teaching content typically focuses on surgical procedures and technical operations, with limited integration of related disciplines such as imaging, pathology, anesthesiology, oncology, rehabilitation medicine and psychological medicine [5]. Although this teaching approach is helpful for basic skills training, it has certain limitations in cultivating students' comprehensive diagnostic and therapeutic thinking, interdisciplinary collaboration, and clinical decision-making abilities [6]. A teaching model that focuses primarily on surgical techniques can therefore hardly meet the training needs of modern thoracic tumor surgery. In recent years, the concept of integrative medicine has received widespread attention in the field of medical education in China. Fan [7] proposed that integrative medicine is not simply the superposition of multidisciplinary knowledge. Rather, based on a comprehensive understanding of the integrity of the human body and the complexity of diseases, it systematically integrates knowledge from basic medicine, clinical medicine, and related disciplines to form a model of medical understanding and treatment that is more consistent with actual clinical needs [7]. This concept has not only promoted the transformation of disease diagnosis and treatment models but has also provided a new theoretical basis for reforming clinical teaching.

In the field of medical education, integrative medicine serves as an overarching philosophical framework that emphasizes holistic clinical thinking beyond traditional disciplinary boundaries, while the multidisciplinary team (MDT) approach functions as a practical model derived from this philosophy [8]. MDT was initially widely applied in tumor diagnosis and treatment, with specialists from surgery, internal medicine, radiology, pathology, anesthesiology and nursing teams jointly participating in the formulation of individualized treatment plans [9]. In recent years, this model has gradually been introduced into clinical teaching, giving rise to multidisciplinary collaborative teaching, an educational approach that applies MDT principles to the training setting. Through case discussions, collaborative perioperative management and interdisciplinary joint teaching, students can develop systematic clinical reasoning and improve their evidence-based analytical ability, teamwork and comprehensive decision-making skills [10]. In thoracic tumor surgery, MDT-based teaching not only helps students understand surgical indications and the timing of treatment, but also strengthens their understanding of the concept of whole-course tumor management [11,12]. The teaching of thoracic tumor surgery is characterized by a high degree of specialization and comprehensiveness. Therefore, integrating the concept of integrative medicine into thoracic tumor surgery education and establishing a teaching model centered on MDT may help overcome the limitations of traditional teaching, enabling students to develop more systematic and comprehensive diagnostic and treatment thinking while mastering essential surgical skills.

Currently, numerous studies have reported the application of the MDT model in clinical oncology practice; however, its educational value in thoracic tumor surgery education has not been systematically investigated, particularly with regard to the evaluation of teaching effectiveness from the perspective of integrative medicine. Therefore, this study developed a multidisciplinary collaborative teaching model based on the concept of integrative medicine and applied it to the clinical teaching of thoracic tumor surgery. By comparing trainees' theoretical knowledge scores, practical skills, clinical reasoning abilities, and teaching satisfaction, this study systematically evaluated the effectiveness of the teaching model, with the aim of providing a reference for the training of high-level clinical professionals in thoracic surgery and the innovation of clinical teaching models.

Methods

Study Design and Participants

This was a single-center retrospective study. The study participants were clinical interns who received clinical training in the Department of Thoracic Disease Diagnosis and Treatment Center at The Third Affiliated Hospital of Jiaxing University (Zhejiang Rongjun Hospital) between March 2022 and March 2025. All research data were retrospectively obtained from the hospital's teaching management system, periodic assessment records, and teaching evaluation records. This study was reviewed and approved by the Medical Ethics Committee of The Third Affiliated Hospital of Jiaxing University (Zhejiang Rongjun Hospital) (approval number: 2026-087), and all research procedures were conducted in accordance with the relevant principles of the Declaration of Helsinki.

Based on the implementation period of the teaching models, the participants were divided into two groups. Thirty trainees who underwent training using the traditional teaching model from March 2022 to August 2023 were included in the control group, while 31 trainees who underwent training using a multidisciplinary collaborative teaching model based on the concept of integrative medicine from September 2023 to March 2025 were included in the observation group. The traditional teaching model mainly consisted of instructor-led lectures, surgical observation, and routine case discussions. In addition to routine teaching, the integrative medicine-based model incorporated multidisciplinary collaborative teaching, discussions on comprehensive perioperative management, integrated case analysis, and team-based collaborative decision-making training to strengthen trainees' comprehensive clinical reasoning and interdisciplinary collaboration abilities.

The inclusion criteria were as follows: (1) clinical interns undergoing standardized training; (2) first-time rotation in

a thoracic surgery-related specialty; (3) participation in the complete clinical teaching program within the prescribed training period and completion of the relevant theoretical and practical assessments; (4) complete attendance records during the training period, with no serious absences; and (5) complete teaching records and assessment materials.

The exclusion criteria were as follows: (1) withdrawal from training before completion or failure to complete all required teaching content; (2) missing key teaching evaluation indicators or assessment data; (3) cumulative absence exceeding 20% of the total teaching time; and (4) inability to complete the final assessment or follow-up evaluation for personal reasons. The participant screening and enrollment process is summarized in Fig. 1.

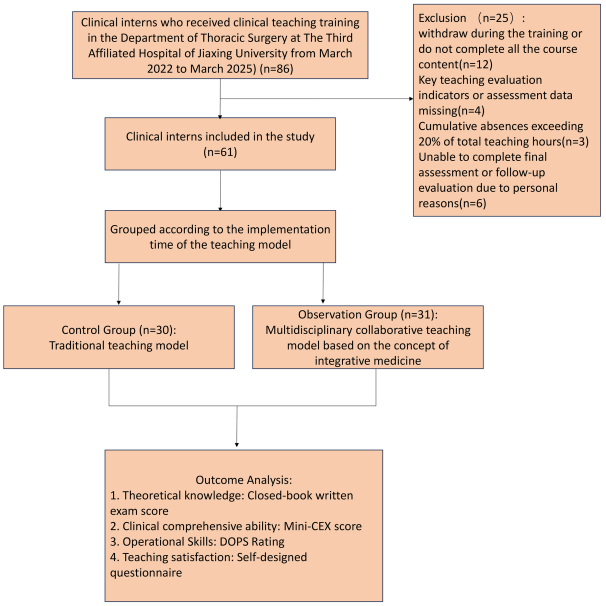


Fig. 1. Participant selection flowchart. DOPS, Direct Observation of Procedural Skills; CEX, Clinical Evaluation Exercise.

Teaching Intervention

Conventional Teaching Model

The control group received traditional clinical teaching in thoracic oncology surgery. The training content was developed according to the standardized training syllabus for clinical interns, and teaching activities were conducted by thoracic surgery instructors. The teaching format primarily combined classroom lectures with clinical observation and covered the basic principles of thoracic tumors, perioperative management, surgical indications, selection of surgical procedures, and management of postoperative complications. Using typical clinical cases, instructors prepared multimedia presentations to systematically explain the diagnostic processes, imaging characteristics, and treatment principles of common thoracic tumors, including lung cancer, esophageal cancer, and mediastinal tumors.

The clinical practice phase primarily employed a "teaching-observation-operation" model. Under the guidance of senior physicians, trainees participated in ward rounds, perioperative case discussions, and surgical observations, with a focus on preoperative assessment, intraoperative cooperation, and postoperative management of patients with thoracic tumors. Skills training mainly consisted of demonstrations of routine procedures, including closed thoracic drainage management, perioperative aseptic techniques, and basic thoracic surgical skills. During the training period, instructors conducted periodic questioning and knowledge assessments; however, standardized multidisciplinary discussions and scenario-based simulations were not included.

To ensure consistency in teaching across different periods, the total teaching hours, number of clinical cases encountered, and training duration for the control group were arranged according to the department's unified teaching plan, ensuring that the training content met the requirements of standardized training. Teaching activities in the control group consisted of weekly theoretical lectures and bedside teaching sessions.

Multidisciplinary Collaborative Teaching Model Based on the Concept of Integrative Medicine

The observation group received traditional teaching supplemented with a multidisciplinary collaborative teaching model based on the concept of integrative medicine. This model centered on the overall patient care process and integrated knowledge from multiple disciplines, including thoracic surgery, oncology, radiology, pathology, anesthesiology, and nursing. Through multi-dimensional collaborative teaching, the model aimed to enhance the clinical decision-making and teamwork abilities of clinical interns. To ensure that the teaching time was consistent with that of the control group, some traditional lecture hours were replaced by multidisciplinary teaching activities rather than being added to the original schedule.

Prior to training, instructors selected representative thoracic tumor cases, including pulmonary nodules, locally advanced lung cancer, esophageal cancer, and complex perioperative cases. Cases were selected based on disease prevalence, diagnostic complexity, and the need for multidisciplinary input, ensuring that they adequately reflected the principles of integrated diagnosis and treatment. Case materials, imaging findings, and relevant clinical guidelines were distributed to trainees in advance, and trainees were required to complete preoperative analyses and formulate treatment plans based on evidence-based medicine data. During the training period, multidisciplinary case discussions were organized once a week, with each session lasting approximately 60 minutes. Instructors from thoracic surgery, radiology, pathology, oncology and anesthesiology jointly reviewed the cases and discussed imaging assessment, pathological classification, surgical planning, pe-

rioperative treatment, and postoperative rehabilitation management, thereby helping trainees develop integrated diagnostic and therapeutic thinking. The MDT teaching team consisted of attending physicians or senior physicians from each participating specialty, all of whom had at least five years of clinical experience in their respective fields. Before the teaching program began, all instructors participated in a two-hour orientation session covering the objectives of the integrated teaching model, the structure of MDT discussions, and the application of standardized assessment rubrics.

In terms of surgical skills instruction, the observation group received simulated surgical training in addition to routine surgical observation. A total of six simulation training sessions were conducted during the 3-month rotation, each lasting 90 minutes, using thoracoscopic simulators and standardized operating platforms. The simulation equipment included a laparoscopic training box with a camera system, basic thoracoscopic instruments, and standardized task modules for grasping, transferring, cutting, and suturing. All training materials, including operation manuals and video demonstrations, were prepared in advance and provided to trainees at the beginning of the rotation. The training covered basic thoracoscopic techniques, instrument coordination, tissue dissection, suturing and knot tying, and management of intraoperative emergencies. Each session followed a structured format: 15 minutes of instructor demonstration, 60 minutes of hands-on practice, and 15 minutes of debriefing and feedback. Scenario-based case exercises were also incorporated to strengthen trainees' understanding of surgical procedures and perioperative decision-making. Training using simulators and standardized operating platforms emphasized procedural standardization, teamwork, and intraoperative communication, with the aim of improving trainees' practical skills and clinical adaptability. In addition, the observation group received scenario-based simulation teaching. Four scenario-based sessions were conducted during the rotation, each lasting 90 minutes, and covered common perioperative clinical scenarios in thoracic tumor surgery, including preoperative communication, perioperative risk assessment, management of postoperative complications, and multidisciplinary comprehensive decision-making. Within the simulated scenarios, trainees were required to complete tasks involving case presentation, clinical decision-making, doctor-patient communication, and teamwork. Each session was facilitated by two instructors, who evaluated trainee performance using a standardized checklist and provided structured feedback immediately after each session.

In addition, the observation group regularly conducted case reviews and group discussions, encouraging trainees to perform literature searches and evidence-based analyses of complex issues in the diagnosis and treatment of thoracic tumors and to optimize treatment plans based on the discussion findings. To ensure consistency in teaching quality across different instructors and sessions, all teaching activities followed predefined templates and standardized assessment rubrics. An independent observer periodically reviewed session recordings to assess adherence to the teaching protocol. To minimize the potential influence of differences in teaching time, both groups followed a unified training cycle and class schedule to ensure comparability of teaching effectiveness.

Training Cycle

Both groups of trainees completed standardized training rotations in the Department of Thoracic Disease Diagnosis and Treatment Center at The Third Affiliated Hospital of Jiaxing University (Zhejiang Rongjun Hospital). According to the hospital's standardized rotation plan for clinical interns, the rotation period in the Department of Thoracic Disease Diagnosis and Treatment Center was 3 months. During the teaching intervention period, the observation group had one case discussion per week, one scenario-based teaching activity every three weeks (four sessions in total over the 3-month rotation), one simulated surgical skills training session every two weeks, and one case review and group discussion every four weeks. The control group followed the department's routine teaching schedule, including one teaching ward round and one theoretical lecture per week. The total rotation duration and total teaching hours were kept consistent between the two groups to ensure balance and comparability in the evaluation of teaching effectiveness.

Baseline Data Collection

Baseline data, including age, gender, baseline entrance examination scores, and prior training experience, were collected from the hospital's standardized clinical intern training information management system. Baseline clinical competence and operational skills were assessed before the teaching intervention using the same assessment criteria as those applied during the post-training evaluations. The assessments were conducted by designated clinical instructors using the Mini-Clinical Evaluation Exercise (Mini-CEX) and Direct Observation of Procedural Skills (DOPS) assessment forms, respectively. Baseline scores were extracted from the hospital's teaching management system and periodic assessment records. Baseline characteristics and assessment scores were compared between the two groups to evaluate their comparability before the teaching intervention.

Evaluation of Teaching Effectiveness

This study primarily assessed the theoretical knowledge, clinical skills, and overall competence of clinical interns undergoing standardized training in thoracic tumor surgery. Upon completion of the training, all trainees underwent a standardized theoretical knowledge assessment and clini-

cal skills evaluation to compare the effectiveness of the two teaching models.

The theoretical knowledge assessment was a closed-book written examination. The examination questions were developed by the department's teaching team based on the standardized training syllabus for clinical interns in thoracic oncology surgery. The examination consisted of three sections: single-choice questions (40 points), multiple-choice questions (20 points), and case-based short-answer questions (40 points). The same examination paper was used for both groups. All papers were scored independently by two instructors using a predefined answer key and scoring rubric, and any discrepancies were resolved through discussion. The examination content covered thoracic tumor epidemiology, imaging interpretation, Tumor-Node-Metastasis (TNM) staging, perioperative management, comprehensive treatment strategies, and management of postoperative complications. The theoretical test score was 100 points, with higher scores indicating a better mastery of theoretical knowledge.

Clinical comprehensive competence was assessed using the Mini-CEX. Each trainee underwent two Mini-CEX assessments during the 3-month rotation (once at mid-rotation and once at the end), using different real or standardized clinical cases selected from common thoracic tumor presentations, in accordance with the assessment frequency recommended in the national residency training guidelines. The assessments were conducted by two senior attending physicians who had received pre-study training on the Mini-CEX rating criteria and assessment procedures. The evaluation mainly included medical history taking and case analysis, clinical reasoning and judgment, doctor-patient communication, and Organization/Efficiency. The Organization/Efficiency domain assessed trainees' ability to organize the diagnostic and treatment process in a systematic and logical manner, manage time effectively, and summarize and present a care plan. Each item was scored on a 20-point scale, with higher scores indicating better comprehensive clinical competence. The mean of the two assessments was used as the final score for each item.

The operational skills assessment was tailored to the characteristics of clinical teaching in thoracic oncology surgery and primarily evaluated trainees' adherence to operational procedures, perioperative teamwork, proficiency in instrument use, and mastery of basic thoracic surgical skills. The assessment was conducted using the Direct Observation of Procedural Skills (DOPS) format, with each trainee assessed twice during the rotation. Assessments were performed by two attending-level instructors who had received the same pre-study training on the DOPS rating criteria. Each assessment included predefined tasks such as closed thoracic drainage management, aseptic technique, and basic thoracoscopic instrument handling. Scoring followed the standardized DOPS rating scale, with each item scored on a 20-point scale. To ensure consistency in scoring, both instructors independently evaluated the same trainee during the first assessment session. Any discrepancies were resolved through discussion to calibrate scoring standards before subsequent assessments were conducted.

The teaching satisfaction survey was conducted anonymously after completion of the training. The questionnaire was self-designed based on a review of the relevant literature on clinical teaching satisfaction assessment and was adapted to the specific content of the teaching intervention. It comprised five items: teaching methods, teaching content, learning enthusiasm, effectiveness, and practicality. Each item was scored on a 20-point scale, the mean of the two assessments was used as the final score for each item with higher scores indicating greater satisfaction. Before formal administration, the questionnaire was pilot-tested among 10 trainees from the previous rotation to assess its clarity and relevance, and minor wording adjustments were made based on their feedback.

Statistical Analysis

Statistical analyses were performed using SPSS 26.0 (IBM Corp., Armonk, NY, USA). The Shapiro–Wilk test was used to assess the normality of continuous variables. Normally distributed data were expressed as mean ± standard deviation ($\bar{x} \pm s$), and between-group comparisons were performed using the independent samples *t*-test (when variances were homogeneous) or Welch's corrected *t*-test (when variances were unequal). Non-normally distributed data were expressed as median (interquartile range) [$M(Q_1, Q_3)$] and compared using the Mann–Whitney U test. Categorical variables were expressed as frequencies and percentages [n (%)], and between-group comparisons were performed using the χ^2 test; Fisher's exact test was used when the expected frequency was <5. All statistical tests were two-tailed, and a p-value < 0.05 was considered statistically significant. A post-hoc power analysis for the primary outcome was performed using G*Power software (version 3.1.9.7; Heinrich-Heine-Universität Düsseldorf, Düsseldorf, Germany), with $\alpha = 0.05$ (two-sided).

Results

Comparison of Baseline Characteristics of the Study Participants

This study included 61 clinical interns, with 30 in the control group and 31 in the observation group. Baseline analysis showed no statistically significant differences between the two groups in theoretical knowledge, history taking and case analysis, clinical reasoning and judgment, doctor-patient communication, operational procedures, teamwork, proficiency in instrument use, or prior training experience (all $p > 0.05$). There were also no statistically significant differences in categorical variables, including gender, or in non-normally distributed continuous variables, including age, Organization/Efficiency, and mastery of basic skills (all $p > 0.05$). These results indicate that the two

Table 1. Comparison of baseline data between the two groups of trainees.

Variables	Control group (n = 30)	Observation group (n = 31)	Statistic	*p*
Age (years)	25.50 (24.00, 26.75)	25.00 (23.50, 28.00)	Z = –0.07	0.942
Gender, n (%)			χ^2 = 0.17	0.684
Female	18 (60.00)	17 (54.84)		
Male	12 (40.00)	14 (45.16)		
Prior training experience			–	0.473
Yes	25 (83.33)	28 (90.32)		
No	5 (16.67)	3 (9.68)		
Theoretical knowledge	73.10 ± 6.70	73.58 ± 7.50	*t* = –0.26	0.793
Comprehensive clinical skills				
Medical history taking and case analysis skills	13.77 ± 1.72	13.77 ± 2.16	*t* = –0.02	0.988
Doctor-patient communication skills	13.60 ± 2.62	13.74 ± 2.83	*t* = –0.20	0.840
Clinical reasoning and judgment ability	13.43 ± 3.13	14.00 ± 1.97	*t* = –0.84	0.403
Organization/Efficiency	13.00 (12.00, 16.00)	15.00 (13.00, 16.00)	Z = –0.96	0.338
Skills assessment				
Operational standardization	13.70 ± 2.05	13.77 ± 3.23	*t* = –0.11	0.915
Teamwork	12.70 ± 3.11	14.16 ± 2.76	*t* = –1.94	0.057
Instrument proficiency	14.73 ± 1.89	15.13 ± 1.80	*t* = –0.84	0.406
Basic skills mastery	15.00 (14.00, 17.00)	15.00 (13.00, 16.00)	Z = –0.82	0.412

Note:"-" indicates that Fisher's exact test was used.

The mean values of some variables may appear identical due to rounding to two decimal places; statistical analyses were performed using the original unrounded data.

Table 2. Comparison of theoretical knowledge and comprehensive clinical competence between the two groups.

Variables	Control group (n = 30)	Observation group (n = 31)	Statistic	*p*
Theoretical knowledge	84.50 ± 6.08	91.65 ± 3.88	*t* = –5.45	<0.001
Comprehensive clinical skills				
Medical history taking and case analysis skills	15.07 ± 1.86	16.35 ± 2.32	*t* = –2.39	0.020
Doctor-patient communication skills	14.70 ± 2.84	15.35 ± 3.20	*t* = –0.84	0.402
Clinical reasoning and judgment ability	14.50 (12.00, 17.00)	18.00 (16.50, 19.00)	Z = –4.05	<0.001
Organization/Efficiency	15.00 (14.00, 16.75)	17.00 (16.00, 18.00)	Z = –3.33	<0.001

groups were comparable in terms of pre-training theoretical knowledge, comprehensive clinical competence, operational skills, and demographic characteristics (Table 1).

Comparison of Theoretical Knowledge and Comprehensive Clinical Competence Between the Two Groups

Post-hoc power analysis for the primary outcome (theoretical knowledge scores) yielded a power of 0.999 (Cohen's d = 1.41). After training, the theoretical knowledge assessment score of the observation group was 91.65 ± 3.88 points, which was significantly higher than that of the control group (84.50 ± 6.08 points), and the difference was statistically significant ($p < 0.05$).

Regarding comprehensive clinical abilities, the observation group scored significantly higher than the control group in history taking and case analysis, clinical reasoning and judgment, and Organization/Efficiency (all $p < 0.05$). However, there was no statistically significant difference in doctor-patient communication skills between the two groups (Table 2).

Comparison of Skill Assessments Between the Two Groups

After training, the observation group scored significantly higher than the control group in operational standardization, teamwork, and proficiency in equipment use (all $p < 0.05$). There was no statistically significant difference in basic skills mastery scores between the two groups ($p = 0.262$; Table 3).

Evaluation of Training Satisfaction Between the Two Groups

After training, the observation group scored significantly higher than the control group in teaching content, teaching methods, learning enthusiasm, and overall satisfaction (all $p < 0.05$). There were no statistically significant differences in effectiveness and practicality scores between the two groups (all $p > 0.05$; Table 4).

Discussion

As the diagnosis and treatment of thoracic tumors continue to develop toward greater precision and comprehensiveness, the traditional teaching model for clinical interns,

Table 3. Comparison of operational skills between the two groups.

Variables	Control group (n = 30)	Observation group (n = 31)	Statistic	*p*
Operational standardization	14.47 ± 2.84	16.97 ± 1.74	*t* = –4.13	<0.001
Teamwork	14.60 ± 2.08	16.23 ± 2.00	*t* = –3.12	0.003
Instrument proficiency	15.00 (14.00, 16.00)	17.00 (16.00, 18.50)	Z = –3.92	<0.001
Basic skills mastery	16.00 (15.25, 17.00)	17.00 (15.00, 18.00)	Z = –1.12	0.262

Table 4. Comparison of post-training satisfaction between the two groups.

Variables	Control group (n = 30)	Observation group (n = 31)	Statistic	*p*
Teaching content	13.10 ± 3.13	15.81 ± 2.36	*t* = –3.82	<0.001
Effectiveness	14.67 ± 2.41	15.74 ± 2.61	*t* = –1.67	0.100
Practicality	15.77 ± 2.05	16.48 ± 2.26	*t* = –1.30	0.200
Teaching methods	14.00 (13.00, 16.75)	17.00 (16.00, 18.50)	Z = –4.99	<0.001
Enthusiasm for learning	14.50 (13.00, 16.00)	17.00 (16.00, 18.50)	Z = –4.13	<0.001
Total score	71.93 ± 5.92	82.48 ± 4.58	*t* = –7.80	<0.001

which focuses mainly on imparting knowledge within a single specialty, can no longer fully meet the needs of clinical practice [13,14,15]. The diagnosis and treatment of thoracic tumors often involve multiple complex stages and are inherently characterized by multidisciplinary collaboration [16]. Therefore, improving the comprehensive clinical abilities of clinical interns through a more systematic and integrated teaching model has gradually become an important direction in medical education research. Based on the concept of integrative medicine, which emphasizes holistic, patient-centered thinking and the integration of knowledge across specialties, this study constructed a multidisciplinary collaborative teaching model as a concrete educational implementation of this philosophy. The results suggest that this teaching approach, grounded in the integrative medicine framework and implemented through MDT-style collaboration, may help improve the clinical training outcomes of thoracic tumor clinical interns.

In this study, the theoretical examination scores of the observation group were significantly higher than those of the control group. This may be related to the fact that multidisciplinary case discussions can promote knowledge integration. In traditional classroom teaching, students rely more on passive knowledge acquisition, whereas the MDT teaching model emphasizes active analysis and problem-oriented learning. Students need to integrate knowledge from multiple disciplines, such as radiology, pathology, surgery, oncology and anesthesiology, to systematically evaluate patients' conditions, thereby deepening their understanding of the diagnosis and treatment process of thoracic tumors. Lütgendorf-Caucig et al. [17] reported that multidisciplinary teaching can significantly improve clinical interns' comprehensive analysis of complex tumor cases and enhance their clinical reasoning ability. The results of the present study are generally consistent with previous reports [17]. In addition to theoretical knowledge, this study also focused on evaluating the comprehensive clinical abilities of clinical interns. The observation group performed better in indicators related to case analysis and clinical decision-making. This may also be related to the MDT discussion model. Multidisciplinary discussions enable students to analyze the same case from different professional perspectives and develop a more comprehensive clinical reasoning model during diagnosis, staging and treatment planning [18]. Through collaborative teaching based on the concept of integrative medicine, trainees may gain a deeper understanding of the roles of different disciplines in the diagnosis and treatment of thoracic tumors, thereby improving their clinical analysis and comprehensive management abilities [19]. Before interpreting the specific findings, it should be noted that multiple indicators were evaluated across different domains, and the possibility of chance findings cannot be completely excluded. However, the assessment items were predefined according to the established teaching evaluation framework, and the observation group showed consistently better performance across most dimensions, supporting the overall reliability of the conclusions. It is worth noting that there was no statistically significant difference in doctor-patient communication scores between the two groups. This result may be related to the fact that the training in this study mainly focused on perioperative decision-making, case analysis and operational skills in thoracic tumor surgery, while humanistic training related to doctor-patient communication was relatively limited. In addition, improvement in doctor-patient communication ability often depends on long-term clinical practice and the gradual development of individual communication skills, and a short-term teaching intervention may not be sufficient to produce significant differences in scores. Therefore, future teaching models should further strengthen specialized training in perioperative communication, humanistic care and psychological support.

In terms of skills assessment, the observation group scored significantly higher than the control group in operational standardization, teamwork and instrument proficiency, while there was no statistically significant difference in ba-

sic skills mastery. This result suggests that the multidisciplinary collaborative teaching model may have a positive effect on improving the quality of thoracic tumor surgery-related operations and perioperative collaboration, but its effect on basic skills may be relatively limited. One possible reason is that trainees in both groups received standardized basic skills training, resulting in no significant difference in the mastery of basic thoracic surgical skills. In contrast, the observation group received additional scenario-based simulation teaching and MDT collaborative training, which emphasized perioperative process management, teamwork and standardized operational requirements. This may explain their better performance in operational standardization and instrument proficiency. A previous study on scenario-based simulation teaching in thoracic surgery has also suggested that this teaching model is more conducive to improving the operational skills and clinical judgment of surgical trainees [20]. The teaching satisfaction results showed that the observation group had higher satisfaction in teaching methods, teaching content, and learning enthusiasm than the control group, while differences in perceived effectiveness and practicality did not reach statistical significance. This suggests that the multidisciplinary collaborative teaching model based on the concept of integrative medicine may help enhance the learning enthusiasm of thoracic tumor clinical interns during training, although improvements were observed in specific assessed dimensions rather than uniformly across all domains. Similar findings have been reported in other medical specialties. For instance, Sui et al. [21] evaluated a scenario simulation combined with Mini-CEX teaching model among obstetrics and gynecology residents and reported improvements in theoretical examination scores, case analysis performance, Mini-CEX assessment scores, and overall teaching satisfaction compared with traditional teaching.

This study still has several limitations. First, it is a single-center retrospective study with a relatively limited sample size, which may introduce selection bias and limit the generalizability of our findings to other training settings with different curricula, case mixes, or assessment standards. While the teaching model showed promising results in our institutional context, its applicability to other centers or residency programs requires further validation. In addition, the two groups were recruited from different time periods rather than being randomized concurrently, which means that changes in clinical practice or teaching conditions over time may have affected the outcomes independently of the teaching model. Although the baseline characteristics were comparable between the two groups, unmeasured confounding factors cannot be completely excluded. Furthermore, this study primarily evaluated short-term teaching effectiveness and lacked long-term follow-up data; therefore, it could not assess the impact of this teaching model on the long-term clinical competence and career development of clinical interns. Also, the assessment tools used in this study were predominantly subjective, including written tests, instructor-administered Mini-CEX assessments, and self-reported satisfaction questionnaires. While these instruments are commonly used in clinical education research, they are influenced by trainees' test-taking ability and instructors' subjective judgment. The absence of more objective measures, such as third-party evaluations, standardized Objective Structured Clinical Examination (OSCE) scores, or independent portfolio assessments, limits the objectivity of our findings. In addition, the teaching satisfaction questionnaire was self-designed and was only pilot-tested for clarity and relevance; formal reliability and validity assessments were not performed. Therefore, the satisfaction findings should be interpreted cautiously, and further validation of the questionnaire is warranted in future studies. In addition, Mini-CEX scores may vary among instructors because of subjective evaluations, which is a common issue in clinical teaching research. Future studies should further expand the sample size and adopt multi-center, prospective designs to further validate the teaching value of this model.

Conclusions

In conclusion, the multidisciplinary collaborative teaching model based on the concept of integrative medicine may improve theoretical knowledge, selected aspects of comprehensive clinical competence, and satisfaction with specific aspects of teaching among clinical interns undergoing thoracic surgery training. By integrating multidisciplinary knowledge, strengthening scenario-based simulation training, and emphasizing the cultivation of holistic clinical thinking, this model provides a new teaching approach for the standardized training of clinical interns undergoing thoracic surgery training and may have potential value for broader clinical teaching application.

Availability of Data and Materials

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Author Contributions

ZZ, GL and YG designed the research study and wrote the first draft. LH, HC, XL, and PC performed the research. YZ and YM analyzed the data. All authors contributed to the critical revision of the manuscript for important intellectual content. All authors read and approved the final manuscript. All authors have participated sufficiently in the work and agreed to be accountable for all aspects of the work.

Ethics Approval and Consent to Participate

This study obtained approval from The Third Affiliated Hospital of Jiaxing University (Zhejiang Rongjun Hospital) (approval number: 2026-087), all participants signed

a written informed consent. All research procedures were conducted in accordance with the relevant principles of the Declaration of Helsinki.

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Conflict of Interest

The authors declare no conflict of interest.

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