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Optimizing anesthesiology education for international students in China: challenges and innovative teaching strategies

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With the accelerated internationalization of medical education in China, education of international students has become a key indicator of overall medical education quality. As a highly integrated discipline, anesthesiology requires teaching models that combine theoretical knowledge with practical training, while addressing the diverse cultural and academic backgrounds of international learners. However, anesthesiology education for international students in China faces distinct challenges related to language barriers, culture adaptation and pedagogical alignment. To enhance the quality of anesthesiology education, it is essential to implement innovative and student-centered teaching strategies tailored to their specific needs. This narrative review summarizes the primary challenges encountered in anesthesiology education for international students in China and proposes innovative, student-centered teaching strategies, including bilingual instruction, hybrid models combining problem-based and case-based learning, simulation-based education, and the application of emerging technologies such as AI-assisted learning. Through the enhancement of clinical exposure and the adoption of interactive methods, medical institutions can achieve greater teaching effectiveness, improve clinical competence, and promote equitable learning experiences, ultimately preparing international students to become competent anesthesiologists capable of meeting global healthcare demands in multicultural medical education settings.

KEYWORDS

anesthesiology education, international students, teaching innovations, medical education, China

1 Introduction

Globalization of medical education has significantly reshaped higher education worldwide, with China emerging as a key destination for international medical students. Driven by the nation's growing influence and the acceleration of educational internationalization, China has actively expanded collaborations with foreign medical institutions. Under the strategy of the “Belt and Road” initiative, the number of international students pursuing medical degrees in China has surged, establishing itself as the largest host country for international students in Asia (Biney and Cheng, 2021; Ke et al., 2022) and the third most popular global destination, attracting nearly 500,000 students, comparable to the United States and the United Kingdom (Shih and Cao, 2022).

Medical education aims to empower students by imparting the knowledge and skills necessary for local and global healthcare. Anesthesiology, as a comprehensive discipline in clinical medicine, intricately integrates foundational biomedical sciences with advanced clinical practice (Yang et al., 2019). However, traditional teaching methods often rely heavily

on rigid, lecture-based approaches that may not effectively support the diverse learning styles and demands of international students. Meanwhile, language barriers, differences in educational backgrounds, and restricted access to clinical practice further impede international students from mastering essential competencies.

To address these challenges, innovative and student-centered teaching strategies are essential for optimizing the anesthesiology education for international students in China. This present review summarizes the key challenges faced by international students in anesthesiology education and explores innovative teaching approaches, including problem-based learning (PBL), case-based learning (CBL), flipped classrooms (FC), simulation-based education, and artificial intelligence (AI)-assisted learning. By adopting these strategies, medical institutions can enhance the effectiveness of anesthesiology education, improve student engagement, and ensure that international graduates develop the necessary skills to thrive in diverse clinical settings.

2 Main challenges in anesthesiology education for international students

Anesthesiology is a highly practical field where anesthesiologists must rapidly identify, diagnose, and manage various perioperative emergencies. Solid knowledge combined with proficient clinical skills is essential to handle emergencies, accidents, and complications during anesthesia and surgery. However, language barriers (Li et al., 2020; Zou et al., 2023), diverse educational backgrounds, and restricted clinical practice opportunities (Zou et al., 2023) among international students in China have resulted in inadequate bidirectional communication in anesthesiology teaching and learning, as well as slower progress in both theoretical and practical instruction.

2.1 Language and communication barriers

Chinese is widely recognized as a complex and challenging language, particularly for individuals whose native languages differ significantly in terms of grammar, phonetics, and writing systems. Despite receiving short-term Chinese language training prior to their studies in China, international students often struggle to communicate effectively with instructors due to the language's complexity and insufficient preparation time. Over 70% of international students in China come from non-English-speaking countries in Asia, Africa and Latin America (Biney and Cheng, 2021), many of whom speak English with strong accents. Since China is also a non-English-speaking country, this linguistic gap frequently leads to communication barriers between instructors and international students (Li et al., 2020). Additionally, students with poorer English tend to be less adept at communication, social interaction, and cultural understanding in healthcare settings, demonstrating more homesickness and achieving inferior academic progress (Wang et al., 2015). These language barriers severely impact the transmission of knowledge between teaching and learning (Jiang et al., 2024b; Liu et al., 2017), and cause some international students to become passive in the learning process (Tan et al., 2022).

2.2 Diverse educational backgrounds

International students came from different countries around the world with varied levels of basic education (Medved et al., 2013). There are significant differences in the overall quality and basic cultural knowledge between international students and domestic medical students who participate in unified entrance examinations. In addition, due to different educational concepts at home and abroad, international students prefer interactive teaching method that allow for spontaneous questioning and timely feedback from instructor. International students in China experience higher acculturative stress than those in developed countries (e.g., Europe, America, and Oceania), particularly those from Africa and Asia (Yu et al., 2014). Socioeconomic status and cultural factors such as values of face and the ideology of individualism and collectivism, significantly contribute to these differences in stress (Yu et al., 2014). Significant variations in educational approaches, medical environments, and a lack of social support further hinder international students' adaptation to domestic teaching methods.

2.3 Limited clinical practice opportunities

Anesthesiology is a highly practical discipline that emphasizes hands-on operation skills, such as tracheal intubation, arterial puncture, central venous puncture, and various nerve blocks. Therefore, anesthesiology teaching requires international students to not only master the theoretical basics of anesthesiology but also need considerable opportunities to practice and communicate (He et al., 2022). In clinical education, communication with patients is a fundamental element of learning. However, compared to their Chinese counterparts, international medical students often encounter language barriers during clinical rotational internships, as Chinese patients rarely speak English. Additionally, foreign interns are less recognized and accepted by Chinese patients, often refusing to allow their participation in clinical practice (Müller-Wolff et al., 2024). All these factors make it difficult for international medical students to integrate theory and practice in clinical settings, significantly reduces the effectiveness of their education.

3 Special characteristics of anesthesiology education

3.1 Complexity of clinical anesthesiology

Anesthesiology is distinct from other disciplines due to its high practicality and the urgency required in managing emergencies promptly. Therefore, education for anesthesiologist focuses on equipping students with high-quality perioperative knowledge, diverse practical skills, critical thinking, and the capacity for continuous learning (Mossenson et al., 2021; Rock, 2000). It involves foundational disciplines such as anatomy, physiology, pathophysiology, and pharmacology, while also integrating knowledge from internal medicine, surgery, emergency medicine, and critical care medicine. The wide scope of knowledge in this discipline makes it difficult for international students to master all related knowledge in a short time. Additionally, anesthesiologists frequently collaborate

with various surgical departments, which necessitates mastering a range of complex and specialized anesthesia techniques. Therefore, anesthesiology education demands an integrated and comprehensive approach to develop both the technical proficiency and interdisciplinary knowledge essential for effective clinical practice, particularly for international students facing additional learning challenges.

3.2 Professionalism of clinical anesthesiologists

Surgeries or invasive treatments require a multidisciplinary team collaboration. Anesthesiologists are responsible for assessing the patient's overall condition before surgery, creating a personalized anesthesia plan (Bastola et al., 2024). The accuracy and success of this plan depend on the anesthesiologist's comprehensive understanding and proficiency in multidisciplinary knowledge and surgical techniques. During the surgery, anesthesiologists need to proficiently manage breathing and circulation, and perform various invasive procedures and monitoring techniques to ensure the safety (Oliveira et al., 2017; Alekseev, 2015). Meanwhile, anesthesiologists are responsible for managing postoperative pain to accelerate patient recovery. In short, accurately assess patient's condition, timely provide interventions, maintain and regulate vital functions, and finally ensure the patient safety during the perioperative period are the primary mission of anesthesiologists (Drake, 2013).

3.3 Integrating technical proficiency and global professionalism in anesthesiology education

Anesthesiology education holds unique significance due to its integration of rapid physiological control, high-stakes decision-making, and multidisciplinary collaboration. One of the most amazing aspects of anesthesia is its ability to induce an instantaneous transition from consciousness to unconsciousness in patients, that is unparalleled in any other in medicine. However, medical students new to the field often focus disproportionately on mastering invasive procedures while overlooking essential skills such as perioperative assessment and the interpretation and regulation of intraoperative vital signs (Spijkerman et al., 2025), which are critical for patients safety and effective clinical care.

Furthermore, the Accreditation Council for Graduate Medical Education (ACGME) in the United States has proposed six core competencies for clinical physicians: patient care, medical knowledge, practice-based learning and improvement, interpersonal and communication skills, professionalism, and systems-based practice (Batalden et al., 2002). Given the inherently collaborative nature of anesthesiology, educators must go beyond technical instruction to foster crisis management, teamwork, and lifelong learning abilities—key components of a clinician's global competence (Yang et al., 2019). Meanwhile, faculty role models significantly influence learner engagement. For instance, a study showed that 94% of students interested in pursuing a career in anesthesia considered the presence of inspiring role models as a decisive factor (Watts et al., 1998). So, instructors should set exemplary standards during anesthesia

management, allowing students to feel the professionalism, communication skills, and interpersonal handling capabilities.

Notably, most international anesthesiology students in China originate from low- and lower-middle-income countries in Asia and Africa, with the majority intending to return home countries after graduation to strengthen the local healthcare system (Li et al., 2020; Jiang et al., 2024b), which also play a valuable role in both the global health workforce. Consequently, the primary goal of educating international students in anesthesiology is to develop qualified medical professionals for their home countries. This dual focus, technical mastery and global professionalism, ensures graduates are equipped to address both immediate clinical demands and long-term healthcare challenges in their home countries.

4 Training faculty for international anesthesia teaching

4.1 Strengthening English teaching proficiency

Effective international anesthesiology education begins with faculty development, and young teachers serve as a driving force within teaching teams (Huhn et al., 2016). Typically, these educators possess impressive academic backgrounds, excellent lifelong learning capabilities, and a rapid adaptability to embrace new concepts, making them the backbone to internationalized education. However, most young teachers still struggle with weak spoken communication and limited medical terminology knowledge. Limited English proficiency among instructors and a lack of confidence are key factors contributing to academic difficulties of international students, often leading to decreased engagement and participation (Jiang et al., 2022). Therefore, it is essential to establish a core team of instructors with overseas academic or clinical experience to ensure foundational language competency (Yang et al., 2019; Rashid et al., 2020). Additionally, the implementation of medical English workshops focusing on anesthesiology terminology and clinical communication scenarios (e.g., preoperative evaluation, pain management protocols) could strengthen instructors' professional language proficiency in real clinical contexts. These immersive, English-only case discussions could reinforce practical language application. Furthermore, the application of AI-powered tools (e.g., speech recognition software) can provide instructors with real-time feedback on pronunciation and fluency, creating a robust system for developing both faculty and student language competencies in authentic clinical settings.

4.2 Implementing bilingual teaching

Clinical training in China requires Chinese proficiency for patient interactions (Liu, 2022). Given that English-speaking patients are exceptionally rare in Chinese healthcare settings, international students lacking basic Chinese proficiency face significant barriers in conducting preoperative evaluations, comprehending patient conditions, and developing appropriate anesthesia plans (Akanuma, 2023). Therefore, bilingual education serves as a critical bridge, enabling international students active communication with patients, understanding and grasp their conditions, shortening their distance,

and ultimately earning patient trust through enhanced clinical interactions (Liu and Chong, 2024). The impact of language proficiency, particularly Chinese competence, on international medical students' clinical performance cannot be overstated. Although theoretical instruction may be delivered in English, clinical practice inevitably demands interaction with Chinese-speaking patients and healthcare staff, where language barriers became acutely apparent. Students with better Chinese speaking skills and active communication initiatives had significantly better clinical experiences, as these skills were crucial in internships and patient care roles. The implementation of bilingual teaching should adopt a progressive approach, aligned with international students' needs and curriculum arrangements. The pedagogical progression should begin with English-dominant instruction supplemented by Chinese, then gradually transition to balanced bilingual teaching while incorporating interactive methodologies such as bilingual anesthesia videos, clinical case discussions, and teaching rounds (Müller-Wolff et al., 2024). Through professional bilingual teaching, instructors can provide international students with practical clinical training, a better understanding of various anesthesia-related issues, and improved clinical anesthesiology education.

5 Innovative teaching approaches for international anesthesiology students

Medical education is designed to provide students with the essential knowledge and skills for success in their future careers. Central to this process, students are the primary focus and driving force behind the education. As the volume of medical information continues to expand, it is essential for students to develop skills in self-directed and lifelong learning (Hoy, 2021). Transitioning from a teacher-centered to a student-centered teaching philosophy marks a fundamental shift in educational philosophy (Bastola et al., 2024). In student-centered approaches, students become active knowledge creators, engaging with tailored learning materials rather than passively relying on textbooks, while instructors serve as facilitators guiding their exploration (Blackburn, 2015). For international anesthesiology students in China, this approach is particularly vital, as they face unique challenges stemming from language barriers, diverse learning styles, and cultural differences. Traditional lecture-based methods, characterized by one-way knowledge transmission, often fail to engage these students effectively. Instead, innovative strategies must address their specific needs while cultivating the critical thinking, procedural competence, and rapid decision-making skills essential for anesthesiology practice.

To meet these demands, contemporary medical education integrates diverse pedagogical approaches, including problem-based learning (PBL), case-based learning (CBL), flipped classrooms, simulation-based training, and one-on-one mentorship (Bastola et al., 2024; Blackburn, 2015). These methods promote active participation, deeper understanding, and personalized learning experiences, aligning anesthesiology education with global standards (Qu et al., 2024). Additionally, artificial intelligence (AI) is emerging as a transformative tool, offering adaptive learning platforms and intelligent feedback systems to further enhance educational outcomes (Connor, 2019). By integrating these innovative approaches, educators can create a

more dynamic, inclusive, and effective learning environment for international students, ensuring their successful transition into clinical practice.

5.1 Problem-based learning (PBL)

PBL represents a paradigm shift in medical education, using clinical problems as the foundation for active learning (Chilkoti et al., 2014). This heuristic approach positions students as primary investigators who collaboratively explore authentic clinical scenarios under faculty guidance. The open-ended nature of PBL fosters critical thinking beyond classroom boundaries, and creates an inclusive environment that promotes learner autonomy and research engagement. A recent study at Xi'an Jiaotong University has introduced English-based PBL into the *Histology and Embryology* course for international medical students, with over 70% of participants reporting high satisfaction and notable improvements in critical thinking and clinical reasoning skills (Hoy, 2021). Particularly valuable for international students, PBL enhances long-term cognitive development through its emphasis on self-directed problem-solving.

The key to PBL lies in the design of problems, which should be based on the overall curriculum and knowledge structure, aligning with course objectives and practical plans. Teachers need to design problems tailored to students' varying levels of understanding of anesthesia theory. While PBL is problem-oriented, it may compromise the completeness of foundational theoretical knowledge. Students with weaker self-directed learning abilities might struggle, leading to confusion, deviation from learning goals, and ultimately inadequate preparation and engagement in PBL courses.

5.2 Case-based learning (CBL)

CBL is a robust clinical teaching methodology that immerses students in authentic patient care scenarios. In this approach, students assume the role of attending physicians, to synthesize and apply theoretical knowledge to conduct comprehensive patient evaluations, formulate differential diagnoses, and develop evidence-based management plans. CBL framework emphasizes self-directed learning through individual case analysis, collaborative group discussions to explore diagnostic and therapeutic alternatives, and faculty-facilitated synthesis of clinical reasoning principles (Duan et al., 2021). When contrasted with PBL, CBL demonstrates distinct advantages in clinical education settings by offering a more structured yet equally interactive approach to learning. While both methods promote active engagement, CBL framework allows for more efficient time utilization through focused clinical scenarios, ensures systematic coverage of core competencies, and provides clearer guidance for learners navigating unfamiliar healthcare systems. This balance of structure and flexibility makes CBL particularly valuable for international medical students, as it maintains the benefits of interactive learning while offering explicit clinical anchors to facilitate adaptation to new medical environments. Qu Qicai et al. demonstrated that CBL methods significantly improved theoretical scores, engagement, and learning efficiency among international anesthesiology students compared to traditional lectures-based methods at the Second Affiliated Hospital of Kunming Medical University (Qu et al., 2018).

However, CBL implementation presents certain challenges. Instructors demands substantial prepare time compared to traditional lectures. Additionally, the structured nature of cases may potentially limit student initiative if not properly balanced with open-ended inquiry. The PBL-CBL hybrid model combines the strengths of both approaches, in which instructors select typical clinical cases to teach, posing questions that encourage students to integrate theoretical knowledge with practical applications, to help students connect theoretical knowledge with real-world applications, thereby enhancing their clinical skills and problem-solving abilities (Yang et al., 2023).

5.3 Flipped classroom

The flipped classroom approach reshapes the traditional teaching paradigm by reversing the roles of classroom and homework time: students learn new content before class, while class time is dedicated to group collaboration and teacher-led Q&A (Martinelli et al., 2017). This pedagogical shift fosters greater student engagement, encourages critical thinking, and facilitates hands-on application in class. In the field of anesthesiology, where both theoretical understanding and procedural competence are equally vital, students can first build a foundation through pre-class online resources, then apply and reinforce this knowledge through in-class simulation and discussion-based training (Kurup and Hersey, 2013). Implementing the flipped classroom model effectively, however, requires robust digital infrastructure and the adoption of innovative teaching tools. In the context of the “Internet Plus” era, online teaching has become an indispensable component of medical education, offering both opportunities and challenges for anesthesiology training. Huang et al. (2022) demonstrated that a flipped classroom model significantly improved academic outcomes for international medical students in anesthesiology, achieving pass rates of 80–86.7% and over 80% student approval for enhancing learning interest, self-directed skills, and clinical competence. Rich multimedia content—including instructional videos, interactive modules, and virtual case simulations—enhances theoretical comprehension and bridges the gap between knowledge and clinical practice. These resources also facilitate interdisciplinary integration, promote deeper understanding through repetition, and support the personalized learning pace of international students.

Evidence suggests that compared with traditional lectures, a flipped classroom model enriched with CBL significantly boosts international students’ motivation and classroom participation. Analysis of clinical case sharpens their ability to pose and solve problems, while structured engagement with medical literature enhances their capacity to connect theory with practice (Yang et al., 2024). Overall, the flipped classroom model offers an adaptable, student-centered framework that aligns well with the learning needs of international anesthesiology students and supports the development of their clinical reasoning and communication skills in a more active and contextualized learning environment.

5.4 Simulation-based teaching

In addition to theoretical knowledge and practical skills, anesthesia practitioners need to develop clinical thinking, judgment,

and effective teamwork, and master handling various emergencies. While the operating room remains a critical setting for clinical training, not all perioperative emergencies can be demonstrated live due to patient safety concerns. Simulation-based teaching addresses this gap by providing a risk-free and immersive setting, allowing learners to engage in realistic clinical situations. This method not only replicates the urgency of perioperative crises but also reinforces the timely decision-making required for effective resolution (Mossenson et al., 2021). Simulation helps international students quickly and effectively grasp knowledge, turning theory into practice (Lim and McIvor, 2015). It also highlights the anesthesiologist’s role as a key member of the multidisciplinary team, emphasizing that crisis management hinges on clear communication and collaborative problem-solving. By repeatedly practicing in simulated high-pressure environments, students develop confidence and proficiency in handling emergencies. A study comparing high-fidelity simulation-based teaching with case-based discussions in terms of student satisfaction and knowledge acquisition found that simulation-based teaching resulted in higher student satisfaction, particularly in the debriefing phase, while both methods showed similar effectiveness in knowledge acquisition (Vijayaraghavan et al., 2019).

5.5 “One-on-One” partnership between domestic and international students

International students often lack opportunities to engage in clinical diagnosis and treatment, impairing their ability to conduct preoperative evaluations and manage anesthesia perioperatively. This lack of engagement not only reduces their clinical exposure but also compromises the overall effectiveness of education. “One-on-One” partnership model represents a structured and evidence-based approach to addressing the multifaceted challenges faced by international medical students while simultaneously enriching the educational experience of domestic students. At its core, the model establishes carefully matched partnerships between domestic and international students, creating a symbiotic relationship that transcends conventional mentoring paradigms. Academically, these partnerships facilitate knowledge exchange through collaborative learning activities such as joint case study analyses, simulation training exercises, and research projects (Szlachta, 2013).

Yang et al. (2022) found that pairing international and local medical students significantly improved attendance and exam performance of international students, while over 80% of domestic students reported enhanced language skills. Therefore, “One-on-One” partnership helps international students overcome integration barriers by facilitating language skills through daily interactions, improving academic expectations via direct mentoring, and reducing isolation through meaningful peer connections (Han, 2023; Zhou et al., 2023). The model incorporates specific interventions to bridge learning style differences, with domestic students typically exhibiting deeper conceptual approaches while international students often demonstrate greater adaptability to blended learning environments (Han, 2023). Importantly, the partnership serves as a crucial psychosocial support mechanism, providing international students with accessible emotional support and practical guidance in navigating both academic systems and healthcare environments (Rekenyi et al., 2023).

5.6 Applications of artificial intelligence (AI) in anesthesia education

China's 'Innovation Action Plan for Artificial Intelligence in Higher Education' advocates accelerating the integration of AI technologies into education to reform traditional teaching methods and enhance educational governance. In anesthesiology, AI is revolutionizing perioperative care, from personalized risk assessments and anesthesia planning to real-time physiological monitoring, robotic assistance during surgical procedures, and optimization of postoperative recovery. These advances not only enhance clinical accuracy and patient safety but also introduce new levels of efficiency and individualized care.

The integration of AI technologies such as machine learning, deep learning, and natural language processing (NLP) represents a transformative shift in medical training, particularly benefiting international students through personalized and adaptive learning approaches. AI-driven adaptive learning platforms offer opportunities for automated feedback, language support, and intelligent assessment, particularly beneficial for international students. Virtual reality (VR) simulations combined with AI create immersive training environments for practicing complex procedures, while intelligent tutoring systems provide 24/7 access to updated clinical knowledge. And AI-powered virtual simulations and deep learning techniques can support immersive VR simulation-based training in anesthetic procedures (Singhal et al., 2023). Collectively, these developments are poised to reshape anesthesiology education by fostering more interactive, data-informed, and competency-based learning experiences (Connor, 2019; Cote and Kim, 2019). Additionally, AI can provide virtual learning assistants to help clinical instructors answer students' questions accurately online, ultimately improving training outcomes and optimizing teaching management. Additionally, the article also discusses ethical and interpretability challenges of AI, which can be integrated into medical curricula to foster students' critical thinking and ethical awareness. Collectively, these applications suggest that AI can significantly enrich anesthesiology education through personalized, interactive, and globally relevant learning approaches. If AI is utilized to design authentic lifelike training simulations and provide students with personalized feedback, anesthesia education might be transformed (Shukla et al., 2024).

6 Optimized strategies for enhancing anesthesiology education

6.1 Implementing bilingual and cultural adaptation programs

Effective anesthesia education for international students requires addressing language barriers, cultural gaps, and institutional support. Instructors need targeted English training—especially in medical terminology and clinical communication—through workshops, immersive practice, and AI-assisted tools. And a phased bilingual curriculum should bridge classroom theory and clinical practice, starting with English-dominant instruction and gradually transitioning to Chinese for real-world application (Tu et al., 2003). In the early stage, instructor is delivered approximately 70% in English, focusing on foundational theories

and standardized protocols to establish a common medical language framework. During the mid-stage, the language ratio shifts to a balanced 50% English and 50% Chinese, emphasizing case-based learning and simulated patient-provider dialogues to enhance both clinical reasoning and communication skills. In the late stage, Chinese becomes the dominant language (around 70%), aligning with real-world clinical practice and the localization of medical protocols, including traditional Chinese medicine (TCM) analgesia methods. To facilitate this transition, progressive Chinese language training should be integrated into the medical curriculum, with an emphasis on perioperative terminology and patient interactions (Imbo and LeFevre, 2011). Additionally, cultural adaptation programs, such as workshops on Chinese healthcare norms and hospital immersion experiences, can facilitate smoother integration into clinical environments. These measures collectively ensure that international students develop both the linguistic proficiency and cultural competence necessary for effective practice in China.

6.2 Innovative teaching strategies

6.2.1 Multi-modal active learning (PBL, CBL, and flipped classroom)

A hybrid pedagogical approach combining PBL, CBL, and the flipped classroom model has proven highly effective in anesthesiology education. PBL engages students in solving real-world clinical scenarios, fostering critical thinking and decision-making skills (Yang et al., 2023). CBL complements PBL by allowing students to analyze clinical cases systematically, bridging the gap between theory and practice (Gold et al., 2020). The flipped classroom model optimizes classroom time by having students review foundational material (e.g., video lectures) beforehand, allowing in-person sessions to focus on interactive discussions, simulations, and hands-on practice (Jia et al., 2023). A hybrid PBL-CBL model can further enhance learning outcomes by integrating structured case discussions with problem-solving exercises (Yang et al., 2023). A recent study at Zhengzhou University in China involving 296 international medical students found that combination CBL with the flipped classroom model in pathophysiology significantly enhanced students' active learning strategies, independent study skills, collaborative learning, and critical thinking, with over 75% expressing satisfaction with this teaching method (Yang et al., 2024). Similarly, Qu et al. (2024) reported that a hybrid PBL (hPBL) model, combining PBL and traditional lectures, improved medical students' performance, practical skills, and self-directed learning in the Molecular Biology course at Beihua University in China.

This multimodal approach is particularly valuable for international anesthesia students as it accommodates diverse learning styles while overcoming language and cultural barriers. By combining PBL's problem-solving emphasis with CBL's clinical relevance and FC's flexible preparation, the method enables students to progressively build both medical knowledge and practical competencies in a supportive environment. The primary benefits include enhanced clinical reasoning skills, improved cross-cultural communication abilities, and better preparation for real-world anesthesia practice in Chinese healthcare settings, all while fostering the self-directed learning skills essential for lifelong professional development.

6.2.2 Simulation-based teaching and AI integration

Modern anesthesiology education increasingly relies on simulation-based training as a foundational methodology for international students. This approach provides an unparalleled safe environment for mastering complex anesthetic procedures, from routine inductions to critical emergency management (Qi et al., 2021). The integration of high-fidelity virtual scenarios with AI-enhanced educational technologies establishes a comprehensive learning system that offers several benefits. First, the immediate performance analytics enable precise competency assessment, allowing for targeted skill improvement (Qi et al., 2021; Cai et al., 2022). Second, the adaptive learning algorithms personalize training trajectories based on individual proficiency levels, optimizing the educational efficiency (Cai et al., 2022). Third, the realistic environmental immersion bridges the gap between theoretical knowledge and clinical application while maintaining absolute patient safety (Varas et al., 2023).

Virtual reality (VR) technology has emerged as a particularly promising tool for enhancing anesthesiology education, especially for international students who often face restricted access to clinical practice. Comparative studies demonstrate that VR-based simulations are as effective as, or even superior to, traditional teaching methods in improving various procedural skills (Eng et al., 2024), offering a viable solution for institutions with limited hands-on training opportunities. Moreover, VR offers high-fidelity, repeatable, and immersive scenarios essential for developing competence in high-stakes environments (Coxe et al., 2025). For international learners, VR addresses multiple challenges simultaneously: overcomes language barriers through customizable interfaces, reduces anxiety through controlled exposure, and compensates for limited clinical rotations through immersive simulations (Covaciu et al., 2023). These strengths underscore VR's potential to bridge the gap between theory and clinical practice, especially for learners navigating unfamiliar healthcare systems. However, to maximize these benefits, institutions must prioritize curriculum standardization (Wang et al., 2025) and develop culturally adapted modules that reflect local clinical practices.

AI technologies in anesthesiology education, while still developing, serve primarily as a supplement rather than a replacement for traditional teaching methods (Shimada et al., 2024). NLP technologies can assist international students in overcoming language barriers by providing real-time feedback on clinical terminology and communication (Li, 2022). However, existing NLP systems struggle to fully comprehend domain-specific medical vocabulary and cultural contexts, limiting their reliability in high-stakes clinical communication scenarios (Reader and Drum, 2025). Similarly, machine learning algorithms offer the potential for personalized learning by adapting content based on students' simulation performance data (e.g., error patterns) (Singhal et al., 2023), but their effectiveness relies heavily on high-quality, standardized datasets, and variability across institutions can result in biased recommendations and limited generalizability (Paiste et al., 2024). AI-driven virtual patient systems (VPS) enable immersive, high-fidelity simulation experiences and automated performance assessments, yet they face technical challenges such as insufficient tactile feedback and limited integration of the full perioperative workflow (Singhal et al., 2023). Overreliance on these platforms may also lead to cognitive detachment from real patient variability, impairing students' adaptability in live clinical settings.

Artificial intelligence tools like ChatGPT serve as valuable adjuncts in anesthesiology education by providing international students with interactive learning support. These platforms facilitate mastery of specialized terminology through real-time Q&A and generate practical exercises including anesthetic induction protocols and drug dosage calculations (Choi et al., 2024). Li Lin et al. evaluated AI-assisted preoperative planning among 40 junior anesthesiology residents, and found that AI-assisted groups using ChatGPT and/or Bing Chat performed significantly higher accuracy and completeness compared to the control group (Li et al., 2024). A recent study demonstrated that AI-assisted ultrasound guidance for interscalene brachial plexus block (ISBPB) significantly enhanced procedural efficiency, accelerated skill acquisition and shortened the learning curve (Chen, 2024). Meanwhile, integration of ChatGPT into hybrid teaching models, such as Problem-Based Learning (PBL) and Flipped Classroom (FC) approaches, has demonstrated significant improvements in student assessment performance (Hui et al., 2025; Hu et al., 2023). This AI-enhanced blended learning paradigm combines the structured methodology of traditional pedagogical frameworks with the dynamic capabilities of artificial intelligence to create a more effective educational experience.

Therefore, both VR and AI offer transformative potential for anesthesiology education—particularly for international student cohorts—by enhancing engagement, supporting individualized learning, and bridging gaps caused by language, access, and cultural barriers. When implemented strategically and ethically, these technologies can complement traditional instructional models, elevate clinical readiness, and cultivate globally competent anesthesiologists.

6.3 Enhancing clinical training and student engagement

6.3.1 Structured clinical rotations and hands-on opportunities

To optimize clinical training for international students, medical institutions should implement structured, competency-based rotation programs that emphasize active participation under supervision. These rotations should be carefully designed to ensure exposure to core anesthesia procedures (e.g., airway management, regional anesthesia, and pain control) as well as perioperative decision-making in diverse clinical settings. Integrating simulation-based training with real patient care allows students to refine technical skills while building confidence in high-stakes environments. Additionally, structured feedback mechanisms, such as direct observation and case debriefings, should be incorporated to reinforce learning. This approach ensures that international students not only meet clinical competencies but also adapt to local healthcare protocols and patient interaction styles, bridging gaps between theoretical knowledge and practical application.

6.3.2 “One-on-one” partnership between domestic and international students

Pairing international students with experienced domestic peers or residents through structured partnership programs fosters bidirectional knowledge exchange and enhances hands-on clinical training. This collaborative model provides international students with personalized guidance in patient communication, procedural

technique refinement, and cross-cultural adaption within authentic clinical environments (Szlachta, 2013). To implement this model effectively, institutions should adopt a multi-phase approach that begins with recruitment and matching, pairing students based on complementary clinical skills and cultural backgrounds to foster mutual learning. This is followed by a structured orientation phase, offering training in intercultural communication, mental health awareness, and mentorship expectations to prepare participants for collaborative engagement. The core activities of the program include clinical case discussions, simulation training, and social integration events that strengthen both academic and interpersonal connections. Finally, ongoing support is essential, including regular check-ins, feedback mechanisms, and academic incentives to sustain engagement, monitor progress, and address emerging challenges throughout the mentorship experience.

For long-term success, the program requires institutional support through faculty oversight, dedicated resources, and continuous evaluation. By systematically addressing academic, cultural, and psychosocial needs through these tailored interactions, medical schools can create sustainable cross-cultural learning environments that benefit both domestic and international students, ultimately producing more culturally competent physicians.

7 Discussion

This narrative review explores the multiple opportunities and challenges encountered by international medical students studying in China, as well as the innovations and strategies currently being implemented in educational programs including enhancement of teachers' English proficiency, improvement of teaching methods, and strengthening of support for international students to help them better navigate these challenges and achieve academic success.

One primary motivations for international students to study medicine in China is economic factors (Jiang et al., 2024a; Jiang et al., 2022). Compared to the United States, Canada, and European countries, the costs of studying in China are relatively lower (Storz, 2022). Additionally, improving Chinese language proficiency, experiencing Chinese culture, enhancing cross-cultural communication skills, and boosting employment competitiveness are also key factors motivating international students to study in China (Ke et al., 2022). Despite the increase in the number of international students, the structure of international education in China lags behind that of developed countries. For instance, in 2016, only 14.4% of international students in China were postgraduates, while in 2015, approximately half of the international students in the U. S. were at the graduate level (Ma and Zhao, 2018).

Language barriers are among the most significant challenges for international anesthesiology students in China. Although the courses offered in English are gradually increasing, they still remain small proportion compared to those in developed countries like Japan, Germany, and France (Müller-Wolff et al., 2024). And only a handful of top Chinese universities have adopted English as a medium of instruction (Zou et al., 2022). Moreover, the percentage of foreign faculty in Chinese higher education institutions is quite low; in 2015, foreign teachers accounted for only 0.67% of the total faculty. Meanwhile, most Chinese instructors and patients communicate in Chinese, creating obstacles for students in clinical learning and

practice. A study revealed that faculty's limited English proficiency hinders teaching effectiveness, while international students' lack of Chinese competency impedes clinical interactions, collectively compromising skill development (Dhaliwal et al., 2025). Anesthesiology, being a highly practical discipline, demands that students not only have a solid theoretical foundation but also engage in extensive hands-on practice. Unfortunately, international students in China often face cultural and language barriers that prevent them from fully participating in clinical experiences (Li et al., 2020; Guitard and Toal-Sullivan, 2023). Consequently, bilingual education plays an indispensable role in anesthesiology education for international students by serving as a vital communicative bridge. This pedagogical approach facilitates more effective patient interactions, allowing students to accurately comprehend medical conditions while establishing therapeutic relationship. Through improved clinical communication, bilingual competency not only narrows the cultural-linguistic gap but also fosters patient confidence and trust in perioperative care (Liu and Chong, 2024). A recent study found that using bilingual simulated patients (B-SPs) significantly improved international medical students' communication skills and performance in medical history collection in China, highlighting the effectiveness of bilingual training in bridging language gaps in clinical education (Zou et al., 2023). In bilingual instruction, students often face significant language-related challenges, such as difficulties in understanding course content and participating in classroom interactions (Hamad et al., 2025). Therefore, bilingual teaching must address two core issues, including limited student language proficiency leading to reduced classroom engagement and insufficient bilingual training for instructors. One practical solution is to adjust the language ratio in stages—starting with a native-language-dominant approach (e.g., 70% English) to ensure content comprehension in the early phase, and gradually transitioning to a target-language focus (e.g., Chinese) to strengthen students' professional communication skills. Additionally, digital technologies such as AI-based translation tools can be integrated to dynamically adapt instruction to students' language levels, thereby improving the overall effectiveness of bilingual classrooms.

In addition to language challenges, international students often struggle to adapt to the Chinese medical education system. A recent study highlighted several common issues, such as the sequencing of the curriculum, delayed exposure to clinical practice, limited hands-on opportunities, and poorly structured examinations (Jiang et al., 2024a; Jiang et al., 2022). These challenges not only lead to academic failures but also restrict students' growth within the Chinese medical education framework. To address these issues, medical institutions in China should increase the proportion of practical courses and integrate clinical content with basic science, while enhancing cultural awareness through cross-cultural communication workshops (Wilczewski and Alon, 2023). These enhancements will help international students better adapt to the specific demands of the curriculum and examination formats. Ongoing refinement of these strategies is essential to meet the evolving needs of international students within China's medical education system.

From the perspective of Hofstede's cultural dimensions theory, national cultures such as power distance and individualism versus collectivism exert a profound influence on student behavior and teacher-student dynamics (Zheng et al., 2025; Offiah et al., 2025; Karunaratne et al., 2025). China's high power distance index (PDI)

fosters a hierarchical learning environment in which students are expected to defer to instructors. Otherwise, face culture emphasizes the importance of preserving reputation and avoiding embarrassment, deeply influencing communication and behavior in hierarchical and social contexts (Lun et al., 2023). Karunaratne et al. found that learners from collectivist and high power distance cultures often avoid questioning authority figures due to hierarchical norms, which may result in a passive learning stance and reduced engagement in classroom discussions (Karunaratne et al., 2025). Similarly, Offiah et al. (2025) illustrated how power distance and uncertainty avoidance reinforce status hierarchies, leading learners to remain silent for fear of losing face or exposing knowledge gaps in public. This cultural norm combined with the face culture significantly inhibit classroom interaction. International students, especially those from similar collectivist societies like East Asian, may fear exposing gaps in their knowledge and thus avoid asking questions or participating in discussions (Lun et al., 2023). Moreover, the desire to preserve face often leads students to avoid publicly challenging teachers, which diminishes the depth of classroom dialogue and critical inquiry. In online settings, these tendencies may manifest in low participation rates in asynchronous forums or a reluctance to engage in peer-to-peer feedback activities. To address these issues, cultural intelligence, the ability to function effectively in culturally diverse settings, plays a key role in student adjustment (Li et al., 2023; Shokrpour et al., 2024). Use of culturally adaptive communication strategies (e.g., anonymous feedback platforms) and progressive interaction (e.g., phased communication tasks) can foster more inclusive learning environments and ease students into active participation, thereby improving cultural integration.

Online education has become increasingly popular among international students in China. However, despite this advantages, many students remains dissatisfaction with its overall effectiveness. A recent study revealed that 63.5% of international medical students enrolled in online education in China were dissatisfied with online learning, with 72% of those expressing dissatisfaction in clinical years (Fatima et al., 2023). While online education is often regarded as a convenient learning mode, it has clear limitations in developing practical skills. The limited interactivity and lack of practical opportunities in online courses hampers students' ability to fully grasp complex anesthesiology concepts and skills. As a result, while online learning serves as a useful educational approach, it cannot replace traditional classroom instruction and hands-on clinical practice. To improve the effectiveness of online anesthesiology education for international students, a series of targeted and evidence-based strategies should be implemented. Blended learning models that combine online theoretical instruction with offline practical training, such as manikin-based simulation, have been demonstrated significant improvement in both theoretical knowledge and clinical competency (Zhao et al., 2024). Additionally, flipped classroom designs including pre-class video learning and in-class discussions, have been shown to enhanced student engagement and improve teacher-student interaction, with satisfaction rate increasing by 33% (Kaushik et al., 2023). To address the limitations of in-person training, immersive 3D virtual simulation, such as airway management modules, can enhance practical skill competency, with studies in related fields showing skill mastery rates reaching (Duffy et al., 2024). Additionally, providing structured emotional support through mentorship and intercultural training improves students' online learning attitudes, with satisfaction

improvement rates as high as 96% and emotional engagement significantly predicting learning satisfaction (Zeeni et al., 2025). Together, these strategies directly address international students' most pressing challenges, such as limited clinical exposure and interaction, and should be supported with quantitative evaluation data to ensure feasibility, cultural adaptation, and instructional effectiveness.

Innovative pedagogical approaches, such as flipped classrooms, PBL, CBL and AI-enhanced learning, offer transformative potential, particularly for international students. These approaches facilitate integration of theoretical knowledge and clinical skills through personalized, interactive, and technology-driven experiences (Singhal et al., 2023; Shimada et al., 2024). However, their implementation also introduces significant challenges. The effectiveness of flipped classroom instruction depends on both stable technological infrastructure (Ren et al., 2022) and students' self-discipline, motivation, and academic preparedness (Xu et al., 2024; Chikeme et al., 2024). Initial interest in the subject and prior academic performance significantly influence students' outcomes in flipped classroom settings. Learners with low self-discipline often struggle with inefficient study habits and difficulty adapting to the demands of pre-class autonomous learning, which may ultimately result in polarized learning outcomes (Chen et al., 2023). Likewise, AI-driven tools, despite offering customized learning pathways and real-time feedback, pose ethical risks related to data privacy, algorithmic bias, and the potential erosion of human mentorship (Koçer Tulgar et al., 2023). Without proper safeguards, overreliance on AI may hinder students' critical thinking, clinical reasoning, and independent problem-solving skills, especially if not complemented by instructor feedback and peer interaction.

To address the potential risks and controversies associated with innovational models in anesthesiology education, including educational inequality, over-reliance on algorithms, and diminished faculty-student interaction, a balanced implementation strategy and multi-level support systems is essential. This should include multi-level support systems that integrate differentiated instructional materials, adaptive learning technologies, and structured peer collaboration to ensure inclusive, effective, and equitable learning outcomes (Bastola et al., 2024; Singhal et al., 2023; Faro et al., 2024). To enhance the effectiveness of flipped classrooms, scaffolded instructional models that include structured pre-class preparation, collaborative in-class learning, and adaptive support for students with varying levels of self-discipline can help mitigate outcome disparities. For students with weaker self-discipline, a phased task checklist can be designed with regular progress reviews incorporated (Ashraf et al., 2024; Hu et al., 2024); for those lacking learning motivation, a points-based reward system may be implemented to enhance engagement, coupled with academic motivation training and psychological resilience building to alleviate academic stress (Faro et al., 2024; Elzeky et al., 2022). Consideration of AI integration, institutions should establish transparent governance frameworks, conduct regular algorithmic bias audits, and ensure that AI serves as a supplemental tool rather than replacing human mentorship (Connor, 2019; Cote and Kim, 2019). These efforts must be supported by ongoing faculty development and systematic student feedback mechanisms to ensure continuous refinement. Together, these measures promote an equitable, ethical, and student-centered learning environment that maximizes the benefits of educational innovation while safeguarding pedagogical integrity.

Academic success should not be measured solely by grades. Research indicates that international students define academic success as the mastery of medical knowledge, clinical skills, and communication abilities—criteria that extend beyond traditional performance metrics (Guterman, 2021). This recognition underscores the importance of practical skills over theoretical knowledge in medical practice, necessitating a shift in teaching focus from merely academic achievement to the development of practical competencies and effective communication skills. Studies have revealed a significant correlation between teacher support and students' positive academic emotions as well as negative emotions (Jiang et al., 2024b; Curry, 2018). Therefore, teaching methods, interaction styles, accessibility, student-teacher relationships and empathy are key determinants for academic success of international students in China.

Medical education plays a pivotal role in strengthening both local and global healthcare systems, particularly in specialized fields such as anesthesiology. The development of key anesthesiology competencies, such as sedation, airway management, mechanical ventilation, is fundamental for management of critical patients (de Almeida Rodrigues et al., 2025). Therefore, the systematic design of an evidence-based anesthesiology curriculum is essential. In practice, educators can structure the teaching into three stages—pharmacology, procedural skills and perioperative management—that align with the core competencies (Chin et al., 2023).

The pharmacology stage is structured into three parts: basic agents (e.g., propofol, opioids, neuromuscular blockers) with emphasis on pharmacokinetics and pharmacodynamics; adjunctive and patient-specific agents targeting to individualized dosing strategies; and emerging anesthetic reflecting the advancements of pharmacology. Similarly, the skill education follows a progressive framework, beginning with basic techniques like mask ventilation and endotracheal intubation, progressing to intermediate skills such as video-laryngoscopy, and finally advancing to emergency procedures like fiberoptic intubation and cricothyrotomy. Each stage is complemented by simulation practice and standardized performance checklists. The perioperative management is organized by anesthesia subspecialty, including obstetric, pediatric, geriatric, and neurosurgical anesthesia, etc. Educators integrate preoperative evaluation, anesthesia plan design, and complication management to encourage active learning and decision-making. Throughout the course, a closed-loop model of pre-class preparation, in-class simulation and discussion, and post-class review is effective in cultivating students' clinical competence and overall professionalism.

This study has several limitations. Firstly, this study exclusively focus on the Chinese educational context and lack of comparative analysis with other developing countries, such as India or Brazil. Second, the study does not address potential gender-based variations in cultural adaptation, which may interact with Hofstede's masculinity-femininity dimension to differently influence engagement.

8 Conclusion

This narrative review highlights the specific challenges faced by international students in anesthesiology education in China, including language barriers, cultural adaptation difficulties, and limited clinical exposure. The key contribution of this study lies in its contextualized analysis and the proposed integration of student-centered, culturally adaptive, and technology-enhanced strategies such as progressive bilingual

instruction, hybrid PBL/CBL models, AI-driven adaptive learning systems, and simulation-based education. Unlike generic teaching reforms, our recommendations are tailored to the linguistic, cultural, and clinical environment of China's medical system, aiming to bridge systemic gaps in the training of global medical professionals. Future research should focus on multi-institutional, longitudinal evaluations of these strategies, assessing clinical competence, communication proficiency, student satisfaction, and long-term career trajectories. And further exploration into the integration of VR/AR technologies, cross-cultural mentorship models, and AI-powered assessment tools may offer additional pathways for innovation in anesthesiology education.

Author contributions

YY: Supervision, Conceptualization, Writing – review & editing, Writing – original draft. YL: Writing – original draft. WW: Conceptualization, Writing – review & editing, Writing – original draft.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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