

Practical Teaching of Clinical Gene Amplification Testing in Laboratory Medicine Education: Experiences and Insights

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Abstract: *The field of laboratory medicine education has significantly evolved, with clinical molecular biology testing techniques now a core part of undergraduate medical laboratory curricula. These courses equip students with essential knowledge and skills for modern diagnostics. The COVID-19 pandemic accelerated the establishment of clinical gene amplification testing laboratories globally. These laboratories, crucial for nucleic acid testing and other molecular diagnostics, enhanced healthcare facilities' capabilities during the pandemic and created opportunities for improving practical teaching in laboratory medicine education. Effective clinical instruction in these laboratories during internships is vital. It helps students understand theoretical knowledge related to clinical molecular biology testing, master common techniques in clinical gene amplification testing, and develop the ability to apply molecular biology testing results in clinical diagnosis, treatment monitoring, and prognosis evaluation. This improves the quality of laboratory medicine education and meets the demand for specialized professionals.*

Keywords: Laboratory Medicine Education, Clinical Molecular Biology Testing, Internship Training, Clinical Gene Amplification Testing Laboratories.

1. Introduction

The field of laboratory medicine education has seen significant evolution, with the undergraduate medical laboratory curriculum now mandating the inclusion of clinical molecular biology testing techniques as a core component. This course provides a comprehensive overview of the fundamental theories, key technologies, and latest advancements in molecular biology testing. It equips students with essential knowledge and skills required for modern laboratory diagnostics [1, 2].

The COVID-19 pandemic has had a profound impact on healthcare systems worldwide and has accelerated the establishment of clinical gene amplification testing laboratories in medical institutions of secondary level and above. These laboratories have become crucial facilities for conducting nucleic acid testing and other molecular diagnostic procedures to combat the virus. Their widespread implementation has not only enhanced the diagnostic capabilities of healthcare facilities during the pandemic but has also created new opportunities for improving and optimizing practical teaching in laboratory medicine education in the post-pandemic era [3, 4].

In this context, effective clinical instruction in clinical gene amplification testing laboratories during the internship period becomes vital. By integrating clinical practice into the learning process, students can gain a deeper understanding of the theoretical knowledge related to clinical molecular biology testing [5]. This hands-on experience enables them to firmly grasp the commonly used techniques in clinical gene amplification testing and expand their knowledge of disease-related specialties. It also helps students develop the ability to apply molecular biology testing results in clinical diagnosis, treatment monitoring, and prognosis evaluation, thereby improving the quality of laboratory of medicine education and meeting the demand for specialized laboratory medicine professionals.

The following sections summarize the experiences and insights gained from clinical instruction in clinical gene amplification testing laboratories for laboratory medicine interns.

2. Inadequate Focus on Curriculum Design Leading to Compressed Internship Schedules

As one of the specialized courses in laboratory medicine, Clinical Molecular Biology Testing Techniques offers an in-depth exploration of the development, applications, and cutting-edge advancements in this field. However, when contrasted with courses like clinical basic testing, clinical biochemical testing, clinical immunological testing, and clinical hematology testing, clinical molecular biology testing has been relatively overlooked in traditional teaching and clinical settings, warranting greater attention [5, 6].

The hospital affiliated with our comprehensive university's medical school hosts medical laboratory interns from various institutions. These students have undergone systematic coursework in medical laboratory science during their school years. Nevertheless, in the internship phase, clinical molecular biology testing is allocated a mere three weeks, significantly less than other specialized courses. This discrepancy stems from historical limitations in experimental teaching resources and the absence of well-established clinical gene amplification testing laboratories, which hindered effective implementation of experimental and clinical teaching in molecular biology testing.

In the post-pandemic era, secondary-level and higher medical institutions in China have set up comprehensive clinical gene amplification testing laboratories with adequate hardware to support internships in clinical molecular biology testing. Leveraging these state-of-the-art laboratories and equipment for undergraduate education in molecular biology

testing will not only optimize laboratory resource utilization but also foster the development of specialized technical talent in this field. It is imperative to enhance the emphasis on clinical molecular biology testing within the curriculum, allocate sufficient internship time, and integrate theoretical knowledge with hands - on experience in clinical settings. This approach will better prepare students for the challenges of clinical practice, improve the overall quality of laboratory medicine education, and meet the growing demand for professionals in molecular biology testing.

3. Internship Challenges Due to Graduation Pressure

Upon entering the internship phase, medical laboratory interns encounter various practical issues, such as preparing for postgraduate entrance exams and seeking employment. Individual differences among interns further complicate the situation. For instance, interns with different first - degree backgrounds exhibit distinct concerns: undergraduate interns prioritize postgraduate studies, while professional training interns (students with a junior college degree) focus on job interviews and probationary work [7]. Both situations significantly distract interns from their studies, and some may even go through the motions during internships, leading to unsatisfactory outcomes.

To address this pressing issue and cultivate outstanding talent in molecular biology testing, it is crucial to align the internship process with students' concerns regarding graduation, employment, and further education. Internship instructors should establish closer connections with students and provide targeted guidance and support. For example, they can offer advice on postgraduate exam preparation or job - seeking skills while encouraging students to apply the knowledge and skills learned during internships to potential research or work scenarios. By demonstrating the relevance of internship experiences to students' future goals, instructors can motivate students to take internships more seriously and improve the overall quality of internship training. This approach not only helps students gain practical skills in molecular biology testing but also enables them to better prepare for their career development, ensuring a smoother transition from campus to workplace.

4. Improvement of Instructors' Professional Competence

As mentioned earlier, during the pandemic, a large number of secondary - level and higher medical institutions in China established well - equipped clinical gene amplification testing laboratories. Meanwhile, numerous laboratory workers, after rapid nucleic acid testing training, moved into clinical molecular biology testing positions [3]. These personnel made great contributions to nucleic acid testing during the pandemic. However, in the post - pandemic era, their lack of fundamental theoretical knowledge and insufficient professional quality stability have become increasingly evident.

Most professionals in this field lack systematic learning in clinical molecular biology testing, and their theoretical knowledge and practical experience are inadequate.

Consequently, the implementation of clinical molecular biology testing internship teaching has been restricted [8]. Therefore, to enhance the quality of internship teaching, it is essential to strengthen the continuing education of these workers and improve instructors' professional competence. This is one of the crucial tasks in improving internship teaching at this stage.

In addition, the rapid development of molecular biology testing technology has put forward higher requirements for instructors' knowledge reserves and updating capabilities. Instructors need to continuously learn the latest research findings and technical methods in the field of molecular biology testing, such as gene sequencing, PCR technology, and gene editing, and integrate them into teaching practice. In this way, they can broaden students' horizons, cultivate students' innovative thinking and practical abilities, and meet the demands of the fast - growing field of molecular biology testing.

Furthermore, in terms of teaching methods, instructors should also actively explore and adopt diverse teaching approaches. For example, in the teaching process of clinical molecular biology testing, case - based teaching can be used to present real - world clinical cases to guide students in analyzing problems and solving problems. This helps students better understand the application of molecular biology testing technology in clinical diagnosis and treatment and improves their clinical thinking ability and problem - solving skills. At the same time, it is also important to strengthen the combination of theory and practice. By providing students with more opportunities for hands - on practice, instructors can help students consolidate their theoretical knowledge and master practical operational skills, thereby improving the overall effectiveness of internship teaching.

In summary, improving instructors' professional competence is not only an important means of enhancing the quality of clinical molecular biology testing internships but also a necessary requirement for cultivating high - quality laboratory medicine professionals. Instructors should continuously improve their professional knowledge and skills, actively explore innovative teaching methods, and provide students with better internship teaching experiences, laying a solid foundation for the development of laboratory medicine.

5. Challenges in Internship Training Due to Limitations in Clinical Molecular Diagnosis Implementation

The limitations in the current medical insurance price management system have significantly impacted the development of molecular diagnostic techniques in clinical settings. These restrictions have led to a notable limitation in the number of projects and technologies that can be carried out in clinical gene amplification testing laboratories. Many new projects and technologies cannot be routinely implemented, which in turn has affected the practical training opportunities for students during their internships. Despite the rapid advancement of molecular biology testing techniques in recent years, this specialized field remains less widespread and has a smaller clinical volume compared to other sub - specialties in the clinical testing domain [8, 9].

The establishment of a rational clinical medical service pricing system and the improvement of an efficient approval mechanism for new projects and technologies have become urgent necessities. Molecular biology testing techniques, such as real - time fluorescent PCR technology, have demonstrated their significance in various clinical scenarios. This includes not only the detection of respiratory pathogens during the pandemic and in the post - pandemic era but also in the precise diagnosis and treatment of critical infections, tumors, and rare diseases. However, the supporting management system for these techniques is still under development.

In response to these challenges, our laboratory has implemented several strategies to optimize the internship experience. We have tailored the internship program to meet the specific needs of our students while aligning with the teaching requirements of their affiliated schools. This includes offering customized learning content and flexible learning schedules. For interns who plan to pursue postgraduate studies, we coordinate with the university to provide study leave for exam preparation. For those who need to attend job interviews or probationary work, we offer flexible internship schedules. Additionally, we emphasize the reinforcement of different clinical molecular biology testing techniques based on individual student needs. Our curriculum ranges from commonly used techniques and routine projects to the main related diseases, important clinical implications, and aspects of laboratory quality management and relevant policies.

By fulfilling the basic internship requirements and simultaneously addressing the personalized learning needs of interns, we aim to stimulate their enthusiasm for learning and enhance their initiative. This approach not only ensures that students gain practical experience in molecular biology testing but also helps to cultivate a deeper understanding of the clinical applications and management aspects of these technologies, better preparing them for their future careers in laboratory medicine.

6. The Significance of Internship Training in Clinical Laboratory Science

Interns serve as a driving force for the advancement of clinical laboratory science. Effective internship training that yields ideal learning outcomes is vital for the discipline's and industry's progress [9, 10]. As clinical instructors in molecular biology testing, we should focus on meeting interns' needs to ensure impactful internship training.

To achieve this goal, we need to create a good learning environment for interns in clinical molecular biology testing. This includes offering them adequate resources, guidance, and support to help them better understand the theoretical foundations and practical applications of molecular biology testing. By doing so, we can better prepare them for future challenges in this specialized field.

Funding

This work was supported by the Joint project of Henan Medical Science and Technology Research Program (LHGJ20190243).

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