

CLINICAL PHARMACOKINETICS: A CHALLENGE IN THE TRAINING OF PHARMACISTS IN MEXICO

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ABSTRACT

Clinical pharmacokinetics is a crucial discipline in pharmaceutical education, as it provides essential knowledge about how drugs are absorbed, distributed, metabolized, and excreted in the human body. This understanding is vital for ensuring safe and effective treatments. However, teaching pharmacokinetics presents challenges, especially in Mexico, where students often struggle with its multidisciplinary nature, which integrates chemistry, biology, physiology, and mathematics. Many students find the subject abstract and difficult to relate to clinical practice. A key challenge is helping students transition from theoretical knowledge to practical application, as individual patient factors, such as age, health, and drug interactions, affect drug responses. To address these issues, innovative teaching strategies are needed, including the use of technological tools like interactive simulations and pharmacokinetic modeling software. These tools can help students grasp complex concepts and promote active learning. Despite these challenges, mastering pharmacokinetics becomes a significant professional strength for future pharmacists. It enables them to make critical decisions in clinical settings, optimize drug therapy, and improve patient outcomes. Pharmacists with strong pharmacokinetic skills play a vital role in healthcare teams, ensuring that medications are used safely and effectively, thereby enhancing the overall quality of patient care.

KEYWORDS: Pharmacokinetics, Pharmacy, Education, Clinical Practice.

INTRODUCTION

Clinical pharmacokinetics is a fundamental discipline within pharmaceutical sciences that underpins clinical practice. Understanding how drugs are absorbed, distributed, metabolized, and excreted in the body is essential to ensure the safety and efficacy of treatments. Pharmacists, as healthcare professionals, have the responsibility to master these concepts to optimize drug therapy for each patient. However, we have noticed that, at our University in Mexico, teaching pharmacokinetics presents significant challenges. The multidisciplinary nature of this science, which integrates knowledge from chemistry, biology, physiology, and mathematics, can be overwhelming for many students. Moreover, the complexity of pharmacokinetic models, as well as the numerous variables influencing individual responses to drugs, make it difficult to comprehend and even more so to apply in practice. Additionally, students in our school often encounter obstacles when transitioning from theoretical concepts to real clinical situations. The interindividual variability in drug response, interactions with other substances, and patients' pathological conditions make pharmacokinetics a highly variable and challenging discipline.^[1] Despite its importance, many students perceive pharmacokinetics as an abstract subject that is difficult to relate to the day-to-day practice of pharmacy. To overcome these difficulties, it is necessary to develop innovative pedagogical strategies that enable students to build a solid foundation in the fundamental principles of pharmacokinetics and apply this knowledge to real clinical situations. The use of technological tools such as simulations and pharmacokinetic modeling software can facilitate the understanding of complex concepts and promote active learning.

The importance of pharmacokinetics extends beyond mere academic knowledge. It plays a fundamental role in the development of professional competencies for future pharmacists, especially in hospital settings, where they are expected to make informed decisions regarding medication management. Through clinical interventions, pharmacists can optimize therapy for individual patients, ensuring that treatments are both effective and safe. A solid knowledge of pharmacokinetics allows pharmacists to adjust doses based on factors such as organ function, age, and concomitant medications, ultimately improving patient outcomes. However, despite the crucial role pharmacokinetics plays in their future careers, many of our students find clinical pharmacokinetics truly overwhelming. Additionally, their heavy reliance on the internet for quick and superficial information has significantly decreased their willingness to engage in more in-depth and analytical study practices. This marked reluctance among our students threatens their ability to fully understand pharmacokinetics, a subject where rote memorization is insufficient, and critical thinking is paramount. In this article, we explore the factors contributing to the difficulty of teaching clinical pharmacokinetics, emphasizing the importance of this discipline for students' future performance as clinical pharmacists. We will also discuss strategies to strengthen their engagement, helping them recognize the potential impact they can have on patient care through thoughtful pharmaceutical interventions.

METHOD

The study focused on the teaching of clinical pharmacokinetics at a university in Mexico. The pedagogical approach integrated multiple scientific disciplines such as chemistry, biology, physiology, and mathematics to convey the complexities of pharmacokinetics. To this end, we discuss the difficulties faced by students in connecting theoretical concepts with clinical applications, and how a pedagogical intervention can include the use of interactive simulations and software to simulate pharmacokinetic profiles or design dosing regimens, facilitating the visualization of pharmacokinetic processes. From our university, we describe this perspective on both barriers and opportunities to

enhance teaching, guiding future recommendations to strengthen the learning of clinical pharmacokinetics, which is essential to the professional profile of clinical pharmacists.

DISCUSSION

THE INTEGRATIVE NATURE OF CLINICAL PHARMACOKINETICS

The importance of pharmacokinetics in clinical practice is undeniable. This area of knowledge helps to understand the processes that a drug undergoes in the human body, including absorption, distribution, metabolism, and excretion. This understanding is essential for ensuring the safety and efficacy of pharmacological treatments, as it allows for dose adjustments and personalized therapy for each patient. However, clinical pharmacokinetics is neither easy to teach nor to learn, as it requires a solid foundation in multiple sciences such as chemistry, biology, physiology, and mathematics, which can be a considerable challenge for many students, especially those who lack the necessary prior knowledge.

MULTIDISCIPLINARY REQUIREMENTS

One of the main challenges in studying clinical pharmacokinetics is its integration of multiple scientific disciplines. In chemistry, for instance, students must learn to understand the molecular structures of drugs, their solubility, permeability, and the chemical reactions that influence their behavior within the body. This knowledge is essential for predicting how drugs will be absorbed, distributed throughout the body, metabolized, and finally excreted or eliminated through pathways such as the kidneys. In biology, and specifically in physiology, a deep understanding of organ systems is equally fundamental to grasp how different organs of the human body process drugs. Furthermore, mathematics plays a central role in pharmacokinetics, as precise calculations are necessary to determine key parameters such as half-life, clearance, and dosing intervals. These calculations are essential for designing treatment regimens that ensure therapeutic efficacy and minimize the risk of adverse effects. Much of the challenge in learning pharmacokinetics lies in the fact that for students without a strong foundation in mathematics, these tasks can seem especially daunting and impede their progress. We have observed that another issue is the lack of interest in analytical reasoning. Despite the importance of these concepts, many students struggle due to a resistance to the type of critical and analytical thinking that pharmacokinetics demands. In this discipline, rote memorization is not enough; a deeper approach is required, one that includes problem-solving and quantitative analysis.^[2] However, many students avoid these cognitive activities, which demand greater mental effort. Another factor that affects our students' learning is the growing trend to avoid traditional study methods, such as detailed reading of textbooks or scientific articles. Instead, students in our professional program prefer to obtain information quickly through the internet, which can lead to a fragmented understanding of concepts. This lack of depth in learning can complicate the integration of theoretical knowledge and its application to real clinical situations.

PRACTICAL APPLICATION AND PEDAGOGICAL STRATEGIES

Pharmacokinetics not only involves the theoretical study of how drugs interact with the body but also requires the ability to apply this knowledge in clinical practice. This is another major challenge for our students, who must learn to manage interindividual variability in the pharmacological response of patients. This drug response is influenced by factors such as age, health status, or the presence of other conditions. In the face of these challenges, it is essential that educational programs adopt innovative pedagogical approaches that allow students to consolidate their knowledge and apply it effectively.^[3] The use of advanced technological tools, such as interactive simulations and software, offers an effective solution to these problems. These technologies allow students to visually and practically experiment with how

different factors affect the behavior of drugs in the human body, facilitating the understanding of abstract concepts and promoting more active learning. Clinical pharmacokinetics is essential for pharmaceutical practice, but it presents significant educational challenges due to its multidisciplinary nature and the need for critical thinking. To overcome these barriers, it is necessary to adopt innovative pedagogical strategies that allow students to acquire a solid and practical understanding, which will help them optimize pharmacological therapy and improve patient care.

PHARMACOKINETICS AS A PROFESSIONAL STRENGTH

For students who accept the challenge of mastering clinical pharmacokinetics, the subject becomes a significant professional strength. Clinical pharmacists with a solid background in pharmacokinetics can perform more complex and impactful interventions, earning the trust of both the healthcare team and patients. By optimizing pharmacological therapy, they contribute to better health outcomes, reduce hospital readmissions, and minimize adverse drug events. Pharmacokinetics also positions pharmacists as key members of multidisciplinary healthcare teams.^[4] Physicians and other healthcare providers rely on the pharmacist's expertise to ensure that medications are administered safely and effectively. A pharmacist with strong pharmacokinetic skills can bridge gaps in patient care by offering insights into how individual patient factors, such as age, weight, or comorbidities, influence pharmacological therapy. This collaboration ultimately benefits the patient, improving the overall quality of care.

CONCLUSION

While teaching clinical pharmacokinetics is undoubtedly challenging, its importance in training competent clinical pharmacists cannot be overstated. Pharmacokinetics equips students with the tools necessary to make informed, life-saving decisions regarding drug therapy. Despite the obstacles posed by its integrative nature and the disinterest many students show toward deep analytical reasoning, academics must strive to demonstrate the practical, patient-centered applications of this discipline. For students at our university who accept the challenge, clinical pharmacokinetics becomes a professional strength, enabling them to make meaningful pharmaceutical interventions that directly improve patient care.

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