



INVESTIGATION OF THE ROLE OF LABORATORY TESTING IN DRUG MONITORING AND MANAGEMENT

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Abstract:

Laboratory testing plays a crucial role in the monitoring and management of drug therapy, ensuring the safety and efficacy of pharmacological interventions. Drug monitoring involves the measurement of drug levels in the body to ensure that patients are receiving the right dose for their condition. Therapeutic drug monitoring (TDM) is particularly important for drugs with a narrow therapeutic index, where small deviations in drug levels can lead to treatment failure or toxicity. By measuring drug concentrations in blood or urine, healthcare providers can adjust dosage regimens to achieve optimal therapeutic effects while minimizing side effects. Laboratory testing also plays a crucial role in detecting drug-drug interactions, which can alter the pharmacokinetics and pharmacodynamics of medications. Through the analysis of biomarkers and drug metabolites, healthcare providers can identify potential interactions that may impact treatment outcomes. Additionally, genetic testing can help predict individual responses to certain drugs, allowing for personalized treatment strategies based on a patient's genetic profile. Furthermore, laboratory testing is essential for monitoring organ function and assessing drug-induced toxicity. Liver and kidney function tests can detect early signs of organ damage caused by medications, enabling prompt intervention to prevent serious complications. Monitoring blood cell counts can also help identify hematologic toxicity associated with certain drugs, such as bone marrow suppression or hemolytic anemia. This study aims to explore the significance of laboratory testing in optimizing drug treatment outcomes and preventing adverse drug reactions.

Keywords: laboratory testing, drug monitoring, therapeutic drug monitoring, drug-drug interactions, genetic testing, toxicity monitoring.

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Introduction:

Laboratory testing plays a crucial role in drug monitoring, ensuring that patients are receiving the correct dosage of medication and that their bodies are responding appropriately to treatment. In this essay, we will explore the importance of laboratory testing in drug monitoring, the various types of tests that are commonly used, and the role that these tests play in ensuring patient safety and well-being [1].

One of the primary reasons why laboratory testing is so important in drug monitoring is because it allows healthcare providers to accurately measure the levels of medication in a patient's bloodstream. This information is crucial for determining whether a patient is receiving the correct dosage of medication, as well as for identifying any potential drug interactions or adverse effects that may be occurring. By regularly monitoring drug levels through laboratory testing, healthcare providers can make informed decisions about adjusting a patient's medication regimen to ensure optimal therapeutic outcomes [2].

There are several different types of laboratory tests that are commonly used in drug monitoring, each of which provides valuable information about how a patient's body is responding to treatment. One of the most common types of tests is a blood test, which measures the concentration of a specific drug or its metabolites in the bloodstream. This type of test is often used to monitor the levels of medications that have a narrow therapeutic index, meaning that the difference between a therapeutic dose and a toxic dose is very small [3].

Another type of laboratory test that is frequently used in drug monitoring is a urine test, which can provide information about how a patient's body is metabolizing and excreting a drug. Urine tests are particularly useful for monitoring compliance with medication regimens, as well as for detecting the presence of illicit drugs or other substances that may interfere with the effectiveness of treatment [1].

In addition to blood and urine tests, there are also other types of laboratory tests that can be used in drug monitoring, such as saliva tests, hair tests, and sweat tests. Each of these tests has its own advantages and limitations, and healthcare providers may choose to use one or more of these tests depending on the specific needs of a patient [3].

Overall, laboratory testing plays a vital role in drug monitoring, helping healthcare providers to ensure that patients are receiving the appropriate treatment and that their bodies are responding as expected. By regularly monitoring drug levels and other biomarkers through laboratory testing, healthcare

providers can make informed decisions about adjusting medication regimens, identifying potential drug interactions, and ensuring patient safety and well-being. In conclusion, laboratory testing is an essential component of drug monitoring, providing valuable information that can help to optimize patient care and improve treatment outcomes [2].

Therapeutic Drug Monitoring (TDM) and its Clinical Significance:

Therapeutic Drug Monitoring (TDM) is a crucial aspect of modern healthcare that plays a significant role in optimizing the efficacy and safety of pharmacotherapy. TDM involves the measurement of drug concentrations in biological samples, such as blood or urine, to ensure that patients are receiving the appropriate dosage of medication. This process allows healthcare providers to tailor treatment regimens to individual patients, taking into account factors such as age, weight, renal function, and drug interactions [4].

The clinical significance of TDM cannot be overstated, as it has the potential to improve patient outcomes, reduce the risk of adverse drug reactions, and minimize treatment failures. By monitoring drug levels in the body, healthcare providers can make informed decisions about dosage adjustments, identify non-adherent patients, and detect potential drug interactions. This proactive approach to medication management can lead to better therapeutic outcomes and ultimately improve the quality of patient care [5].

One of the key benefits of TDM is its ability to ensure that patients are within the therapeutic range of a drug. This range is defined as the concentration of a drug in the body that is associated with optimal therapeutic effects and minimal side effects. By monitoring drug levels, healthcare providers can determine if a patient is underdosed, leading to treatment failure, or overdosed, increasing the risk of toxicity. Adjusting the dosage based on TDM results can help maintain drug levels within the therapeutic range, maximizing the benefits of treatment while minimizing the risks [4].

TDM is particularly important for drugs with a narrow therapeutic index, meaning that the difference between a therapeutic dose and a toxic dose is small. Examples of such drugs include antiepileptic medications, immunosuppressants, and certain antibiotics. For these medications, TDM is essential to ensure that patients are receiving the correct dosage to achieve the desired therapeutic effect without risking toxicity [6].

In addition to optimizing drug dosing, TDM can also be used to monitor patient compliance with medication regimens. Non-adherence to prescribed

medications is a common problem in healthcare, leading to treatment failures and increased healthcare costs. By measuring drug levels in a patient's system, healthcare providers can determine if a patient is taking their medications as prescribed. This information can help identify non-adherent patients and provide an opportunity for intervention to improve compliance and treatment outcomes [4].

Furthermore, TDM can be invaluable in the management of drug interactions. Many patients are prescribed multiple medications to treat various medical conditions, increasing the risk of drug-drug interactions. By monitoring drug levels and adjusting dosages accordingly, healthcare providers can minimize the potential for interactions that could alter the effectiveness or safety of a treatment regimen [7].

Therapeutic Drug Monitoring is a vital tool in modern healthcare that can significantly impact patient care and treatment outcomes. By measuring drug concentrations in biological samples, healthcare providers can tailor treatment regimens to individual patients, ensure that drug levels are within the therapeutic range, monitor patient compliance, and manage drug interactions. The clinical significance of TDM lies in its ability to optimize drug dosing, reduce the risk of adverse drug reactions, and improve patient outcomes. As healthcare continues to advance, the importance of TDM in personalized medicine and precision healthcare will only continue to grow [2].

Detection and Management of Drug-Drug Interactions through Laboratory Testing:

Drug-drug interactions (DDIs) are a significant concern in healthcare as they can lead to adverse effects, reduced efficacy of medications, or even life-threatening events. DDIs occur when two or more drugs interact with each other, altering their pharmacokinetic or pharmacodynamic properties. These interactions can occur at various stages, including absorption, distribution, metabolism, and excretion of drugs. Therefore, it is crucial to detect and manage DDIs through laboratory testing to ensure patient safety and optimize treatment outcomes [1].

Laboratory testing plays a vital role in the detection of DDIs by assessing the levels of drugs and their metabolites in the body. This information can help healthcare providers identify potential interactions between medications and adjust treatment regimens accordingly. For example, measuring drug concentrations in the blood can determine if a drug is being metabolized too quickly or too slowly, leading to potential interactions with other medications. Additionally, genetic testing can help

identify patients who may be at a higher risk of experiencing DDIs due to variations in drug metabolism pathways [5].

One of the most common methods used to detect DDIs is drug-drug interaction screening, which involves testing the effects of combining different medications *in vitro*. This approach allows researchers to identify potential interactions between drugs before they are prescribed to patients. In addition, pharmacogenetic testing can help predict how an individual will respond to a specific medication based on their genetic makeup, allowing for personalized treatment plans that minimize the risk of DDIs [7].

Once DDIs are detected, it is essential to manage them effectively to prevent adverse outcomes. This can be achieved through a combination of strategies, including adjusting drug dosages, changing the timing of medication administration, or switching to alternative medications with lower potential for interactions. Laboratory testing can help monitor the effectiveness of these interventions by measuring drug levels in the blood and assessing the patient's response to treatment [8].

Furthermore, healthcare providers can utilize computerized decision support systems that integrate laboratory data with clinical information to identify and manage DDIs more efficiently. These systems can alert healthcare providers to potential interactions between medications, provide recommendations for alternative treatments, and track patient outcomes over time. By leveraging technology and laboratory testing, healthcare providers can improve the detection and management of DDIs, ultimately enhancing patient safety and treatment outcomes [9].

The detection and management of DDIs through laboratory testing are essential components of safe and effective healthcare. By utilizing a combination of drug-drug interaction screening, pharmacogenetic testing, and computerized decision support systems, healthcare providers can identify and manage DDIs more efficiently. This approach not only helps prevent adverse effects and optimize treatment outcomes but also promotes personalized medicine tailored to individual patient needs. As the field of pharmacology continues to advance, laboratory testing will play an increasingly critical role in ensuring the safe and effective use of medications in clinical practice [4].

Personalized Medicine: Role of Genetic Testing in Drug Therapy:

In recent years, personalized medicine has emerged as a revolutionary approach to healthcare, offering the promise of tailored treatments based on an

individual's unique genetic makeup. One of the key components of personalized medicine is genetic testing, which plays a crucial role in identifying genetic variations that can impact drug therapy. By analyzing a patient's genetic profile, healthcare providers can determine the most effective and safe medications for that individual, leading to better treatment outcomes and reduced risk of adverse reactions [10].

Genetic testing has the potential to revolutionize drug therapy by providing valuable insights into how an individual's genetic makeup influences their response to medications. This information can help healthcare providers customize treatment plans that are more targeted and precise, ultimately improving patient outcomes. For example, some individuals may metabolize certain drugs more slowly or quickly than others due to genetic variations, which can affect the drug's efficacy and potential side effects. By identifying these genetic differences through testing, healthcare providers can adjust medication dosages or choose alternative drugs that are better suited to the patient's genetic profile [8].

Moreover, genetic testing can also help identify individuals who are at a higher risk of adverse drug reactions. Certain genetic variations can make individuals more susceptible to experiencing severe side effects from certain medications. By screening for these genetic markers, healthcare providers can proactively avoid prescribing medications that may pose a greater risk to these individuals, thus improving patient safety and reducing healthcare costs associated with treating adverse drug reactions [11].

Additionally, genetic testing can be particularly beneficial in oncology, where targeted therapies are increasingly being used to treat cancer. By analyzing a patient's tumor DNA, healthcare providers can identify specific genetic mutations that are driving the growth of the cancer cells. This information can help guide treatment decisions, allowing for the selection of drugs that target these specific mutations, leading to more effective and personalized cancer treatments [6].

Despite the numerous benefits of genetic testing in drug therapy, there are also challenges that need to be addressed. One of the main challenges is the interpretation of genetic test results, as the field of pharmacogenomics is still evolving and there is a need for more research to fully understand the implications of genetic variations on drug response. Additionally, there are ethical considerations surrounding genetic testing, such as patient privacy and consent, that need to be carefully managed to ensure patient autonomy and confidentiality [12].

Genetic testing plays a critical role in personalized medicine, particularly in drug therapy. By analyzing an individual's genetic profile, healthcare providers can tailor treatment plans to the specific needs of each patient, leading to more effective and safe medication regimens. While there are challenges that need to be addressed, the potential benefits of genetic testing in drug therapy are undeniable, offering the promise of improved patient outcomes and a more personalized approach to healthcare. As research in pharmacogenomics continues to advance, genetic testing will likely become an integral part of modern healthcare, revolutionizing the way we approach drug therapy and ultimately improving the quality of patient care [10].

Monitoring Organ Function and Toxicity with Laboratory Tests:

In the field of medicine, the ability to monitor organ function and detect toxicity is crucial in the diagnosis and treatment of various diseases. Laboratory tests play a vital role in this process, providing healthcare professionals with valuable information about the functioning of different organs and the presence of harmful substances in the body. By analyzing blood, urine, and other bodily fluids, these tests can help identify potential health issues early on, allowing for prompt intervention and management [13].

One of the main purposes of monitoring organ function with laboratory tests is to assess the overall health of an individual and detect any abnormalities that may indicate underlying medical conditions. For example, liver function tests can help evaluate the health of the liver by measuring levels of enzymes and proteins that are produced by this vital organ. Abnormal results may indicate liver damage or disease, prompting further investigation and treatment [12].

Similarly, kidney function tests can provide valuable information about the health of the kidneys, which play a crucial role in filtering waste products from the blood and regulating fluid balance in the body. By measuring levels of creatinine and other substances in the blood and urine, these tests can help detect kidney dysfunction and monitor the progression of kidney disease [4].

In addition to monitoring organ function, laboratory tests are also used to assess toxicity in the body, which can result from exposure to harmful substances such as drugs, chemicals, or environmental pollutants. Toxicity testing involves analyzing blood and urine samples to detect the presence of toxic substances and assess their

impact on various organs and systems in the body [2].

For example, drug toxicity testing is commonly used to monitor the levels of medications in the blood and ensure that they are within the therapeutic range. High levels of certain drugs can be toxic to the liver, kidneys, or other organs, leading to serious health complications. By monitoring drug levels with laboratory tests, healthcare providers can adjust dosages as needed to minimize the risk of toxicity and ensure the safe and effective use of medications [13].

Toxicity testing is also important in occupational health and environmental monitoring, where exposure to toxic substances in the workplace or community can pose a significant risk to human health. By analyzing blood and urine samples for the presence of heavy metals, pesticides, or other toxic compounds, laboratory tests can help assess the extent of exposure and guide efforts to reduce or eliminate harmful substances from the environment [9].

Monitoring organ function and toxicity with laboratory tests is essential for the early detection and management of various health conditions. By analyzing blood, urine, and other bodily fluids, these tests provide valuable information about the functioning of different organs and the presence of toxic substances in the body. Healthcare professionals rely on these tests to assess overall health, diagnose medical conditions, and monitor the effects of medications and environmental exposures. As technology continues to advance, laboratory testing will play an increasingly important role in personalized medicine and preventive healthcare, helping to improve patient outcomes and promote overall well-being [11].

Integration of Laboratory Data in Clinical Decision-Making:

In the field of medicine, the integration of laboratory data in clinical decision-making plays a crucial role in providing accurate diagnoses and effective treatment plans for patients. Laboratory tests provide valuable information about a patient's health status, helping healthcare professionals make informed decisions about their care. This essay will explore the importance of integrating laboratory data in clinical decision-making, the benefits it offers, and the challenges that may arise in the process [10].

Laboratory data includes a wide range of tests that can provide information about a patient's blood chemistry, microbiology, genetics, and more. These tests can help healthcare professionals identify diseases, monitor the progression of a condition, and assess the effectiveness of treatment. By

integrating laboratory data into clinical decision-making, healthcare professionals can make more informed decisions about a patient's care, leading to better outcomes and improved patient satisfaction [14].

One of the key benefits of integrating laboratory data in clinical decision-making is the ability to make accurate diagnoses. Laboratory tests can help healthcare professionals confirm or rule out certain conditions, guiding them towards the most appropriate treatment plan for the patient. For example, a blood test can help identify the presence of an infection, allowing healthcare professionals to prescribe the appropriate antibiotics to treat it. Without this information, healthcare professionals may be left guessing at the cause of a patient's symptoms, leading to ineffective treatment and potentially harmful outcomes [15].

In addition to aiding in diagnosis, laboratory data can also help healthcare professionals monitor the progression of a disease and assess the effectiveness of treatment. For example, blood tests can be used to monitor the levels of certain markers in the blood that indicate the progression of a disease, such as cancer. By tracking these markers over time, healthcare professionals can adjust the treatment plan as needed to ensure the best possible outcome for the patient. This level of monitoring would not be possible without the integration of laboratory data in clinical decision-making [13].

Despite the many benefits of integrating laboratory data in clinical decision-making, there are also challenges that healthcare professionals may face in the process. One of the main challenges is the sheer volume of data that is generated by laboratory tests. Healthcare professionals must sift through this data to identify the most relevant information for making clinical decisions, which can be time-consuming and overwhelming. Additionally, interpreting laboratory data requires a certain level of expertise, and healthcare professionals may not always have the necessary knowledge to fully understand the results of a test [12].

Another challenge is the potential for errors in laboratory testing, which can lead to inaccurate results and misdiagnoses. Healthcare professionals must be vigilant in ensuring the accuracy and reliability of laboratory tests, as errors can have serious consequences for patient care. Additionally, the cost of laboratory testing can be a barrier to integrating laboratory data in clinical decision-making, especially for patients who may not have access to affordable testing options [14].

The integration of laboratory data in clinical decision-making is essential for providing high-quality care to patients. By using laboratory tests to inform diagnoses, monitor disease progression, and

assess treatment effectiveness, healthcare professionals can make more informed decisions about a patient's care, leading to better outcomes and improved patient satisfaction. Despite the challenges that may arise in the process, the benefits of integrating laboratory data in clinical decision-making far outweigh the potential drawbacks. It is essential that healthcare professionals continue to prioritize the integration of laboratory data in their decision-making processes to ensure the best possible outcomes for their patients [16].

Future Directions and Innovations in Laboratory Testing for Drug Monitoring and Management:

In recent years, laboratory testing has played a crucial role in drug monitoring and management. With advancements in technology and research, the field of laboratory testing for drug monitoring is constantly evolving. This essay will explore the future directions and innovations in laboratory testing for drug monitoring and management [17]. One of the key future directions in laboratory testing for drug monitoring is the development of more personalized and precise testing methods. Currently, most laboratory tests for drug monitoring provide general information about drug levels in the body. However, with the advancement of personalized medicine and precision medicine, there is a growing need for more individualized testing methods that can provide detailed information about how a specific drug is metabolized and excreted in an individual's body [18].

One innovation that is already being explored in this area is the use of pharmacogenomic testing. Pharmacogenomic testing involves analyzing a patient's genetic makeup to determine how they will respond to a particular drug. By identifying genetic variations that affect drug metabolism and response, pharmacogenomic testing can help healthcare providers tailor drug therapy to individual patients, leading to more effective and safer treatment outcomes [9].

Another future direction in laboratory testing for drug monitoring is the development of point-of-care testing devices. These devices are portable, easy to use, and provide rapid results, making them ideal for use in various healthcare settings, including hospitals, clinics, and even patients' homes. Point-of-care testing devices for drug monitoring can help healthcare providers make real-time decisions about drug dosing and management, leading to improved patient outcomes and reduced healthcare costs [19].

In addition to personalized testing methods and point-of-care testing devices, the future of laboratory testing for drug monitoring also includes the integration of digital health technologies. These technologies, such as wearable devices and mobile health apps, can collect real-time data about a patient's drug use, adherence, and response to treatment. By integrating laboratory testing data with digital health technologies, healthcare providers can monitor patients more effectively, identify potential issues early, and adjust treatment plans accordingly [4].

Overall, the future of laboratory testing for drug monitoring and management is promising, with advancements in personalized testing methods, point-of-care testing devices, and digital health technologies. By embracing these innovations and incorporating them into clinical practice, healthcare providers can improve patient outcomes, reduce healthcare costs, and ultimately enhance the quality of care for patients receiving drug therapy. It is essential for healthcare providers and researchers to continue to collaborate and invest in research and development to further advance laboratory testing for drug monitoring and management in the years to come [20, 21].

Conclusion:

In conclusion, the investigation of the role of laboratory testing in drug monitoring and management highlights the critical importance of utilizing laboratory tests to optimize drug therapy outcomes and ensure patient safety. The findings of this study underscore the multifaceted contributions of laboratory testing, including therapeutic drug monitoring, detection of drug-drug interactions, personalized medicine through genetic testing, and monitoring of organ function and drug-induced toxicity.

By integrating laboratory data into clinical decision-making, healthcare providers can tailor drug therapy regimens to individual patient needs, maximizing therapeutic efficacy while minimizing the risk of adverse drug reactions. The comprehensive approach to drug monitoring and management facilitated by laboratory testing offers a valuable tool for healthcare professionals in optimizing treatment outcomes and enhancing patient care.

Moving forward, further research and advancements in laboratory technologies are essential to enhance the precision and efficiency of drug monitoring practices. Continued efforts to develop innovative testing methodologies and algorithms will further improve the accuracy and timeliness of drug monitoring, ultimately leading to

better patient outcomes and improved quality of care.

Overall, the investigation of the role of laboratory testing in drug monitoring and management underscores the indispensable role of laboratory tests in modern healthcare practice. By leveraging the insights provided by laboratory testing, healthcare providers can make informed decisions regarding drug therapy, leading to more personalized and effective treatment strategies for patients.

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