Analysis of Preanalytical Errors in a Clinical Chemistry Laboratory - Narrative Review

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Abstract:
Preanalytical errors are a significant concern in clinical chemistry laboratories, as they can lead to inaccurate test results and potentially impact patient care. This narrative review aims to analyze the types, frequencies, and sources of preanalytical errors in clinical chemistry laboratories, as well as discuss strategies for their prevention and management. A comprehensive literature search was conducted using various databases, and relevant studies were included in this review.

INTRODUCTION:

Clinical chemistry laboratories play a crucial role in healthcare by providing accurate and reliable test results to aid in the diagnosis, treatment, and monitoring of various medical conditions (Kalra & Kopargaonkar, 2016). However, the preanalytical phase, which includes all processes from test ordering to sample analysis, is highly vulnerable to errors (Baron, Mermel, Lewandrowski, & Dighe, 2012). Preanalytical errors account for up to 70% of all laboratory errors and can have serious consequences for patient safety and healthcare quality (Agarwal, 2013; Kalra & Kopargaonkar, 2016). Identifying and addressing these errors is essential for ensuring the accuracy and reliability of laboratory test results (Plebani, 2012). The purpose of this narrative review is to explore the different aspects of preanalytical errors in clinical chemistry laboratories and provide insights into their prevention and management.

Types and Frequencies of Preanalytical Errors:

Preanalytical errors can be classified into various categories, including patient identification errors, sample collection errors, sample transportation errors, and sample preparation errors (Agarwal, 2013; Nguyen & Wahed, 2019). Studies have reported varying frequencies of preanalytical errors in clinical chemistry laboratories, ranging from 0.2% to 75% (Cornes et al., 2016; Najat, 2017; Zaini, Dahlawi, & Siddiqi, 2016). The most common types of preanalytical errors include hemolysis, insufficient sample volume, clotted samples, and incorrect sample containers (Dikmen, Pinar, & Akbiyik, 2015; Najat, 2017; Zaini et al., 2016). Hemolysis alone can account for up to 60% of all rejected samples in clinical laboratories (Lippi et al., 2011; McCaughey et al., 2017). These errors can significantly impact the accuracy and reliability of laboratory test results, leading to potential misdiagnosis or inappropriate treatment (Plebani, 2015).

Sources of Preanalytical Errors:

Preanalytical errors can originate from multiple sources, including healthcare providers, patients, and laboratory personnel (Hawkins, 2012). Misidentification of patients, improper sample collection techniques, and inadequate sample transportation and storage conditions are among the major contributors to preanalytical errors (Newman-Toker & Makary, 2013; Tran & Liu, 2020). Additionally, lack of standardization in preanalytical processes and insufficient training of personnel can also lead to errors (Dikmen et al., 2015; Sharaki, Abouzeid, Hossam, & Ahmed, 2014). Studies have shown that up to 50% of preanalytical errors can be attributed to human factors, such as non-compliance with standard operating procedures and poor communication among healthcare providers (Grecu, Vlad, & Dumitrascu, 2014; Teshome, Worede, & Asmelash, 2021). Identifying the sources of preanalytical errors is crucial for developing targeted

interventions and quality improvement initiatives (Plebani, 2012).

Impact of Preanalytical Errors on Patient Care:

Preanalytical errors can have significant implications for patient care, as they can lead to inaccurate test results, delayed diagnoses, inappropriate treatments, and increased healthcare costs (Newman-Toker & Makary, 2013; Tadesse et al., 2018). For example, hemolysis, one of the most common preanalytical errors, can interfere with the measurement of various analytes and lead to false-positive or false-negative results (Lippi et al., 2011; McCaughey et al., 2017). Misidentification of patients can result in the wrong tests being performed or incorrect results being reported, potentially leading to adverse patient outcomes (Tran & Liu, 2020). Preanalytical errors can also lead to unnecessary repeat testing, which increases the burden on laboratory resources and healthcare costs (Agarwal, 2013; Teshome et al., 2021). Reducing preanalytical errors is essential for improving patient safety, healthcare quality, and cost-effectiveness (Plebani, 2015).

Prevention and Management Strategies:

Implementing effective prevention and management strategies is crucial for minimizing preanalytical errors in clinical chemistry laboratories. These strategies include:

1. Standardization of preanalytical processes: Developing and adhering to standardized procedures for patient identification, sample collection, transportation, and preparation can help reduce variability and errors (Simundic et al., 2015; Teshome et al., 2021). The use of checklists, standard operating procedures, and quality control measures can ensure consistency and compliance with best practices (Kalra & Kopargaonkar, 2016; Llopis et al., 2017). Standardization of preanalytical processes can help minimize human errors and improve the overall quality of laboratory services (Plebani, 2012).
2. Training and education: Providing regular training and education to healthcare providers, patients, and laboratory personnel on proper preanalytical practices can improve compliance and reduce errors (Sharaki et al., 2014; Teshome et al., 2021). Educational interventions, such as workshops, e-learning modules, and on-the-job training, can help raise awareness and promote best practices (Agarwal, 2013; Codagnone, Alencar, Shcolnik, & Chaves, 2014). Continuous education and competency assessment are essential for ensuring that all stakeholders have the necessary knowledge and skills to minimize preanalytical errors (Plebani, 2015).
3. Quality control and monitoring: Implementing quality control measures, such as monitoring preanalytical error rates and conducting root cause analysis, can help identify and address sources of errors (Kalra & Kopargaonkar, 2016; Pothula, Al-Marzooq, Salem, AL-Jasem, & AlHajji, 2019). The use of quality indicators and benchmarking can help track performance and drive continuous improvement (Codagnone et al., 2014; Llopis et al., 2017). Regular monitoring and reporting of preanalytical errors can help identify areas for improvement and evaluate the effectiveness of interventions (Plebani, 2012).
4. Automation and technology: Utilizing automated sample processing systems and information technology solutions, such as barcoding and electronic test ordering, can minimize human errors and improve efficiency (Campana, Oplustil, & Faro, 2011; Codagnone et al., 2014). Automation can also help standardize preanalytical processes and reduce variability (Hawkins, 2012; Teshome et al., 2021). The use of technology can enhance patient identification, sample tracking, and data management, thereby reducing the risk of preanalytical errors (Plebani, 2015).
5. Communication and collaboration: Fostering effective communication and collaboration among healthcare providers, patients, and laboratory personnel can help ensure accurate and timely test results (Grecu et al., 2014; Hawkins, 2012). The use of interdisciplinary teams, regular meetings, and clear communication channels can promote a culture of quality and safety (Kalra & Kopargaonkar, 2016; Pothula et al., 2019). Effective communication can help clarify test orders, provide instructions for sample collection, and ensure timely reporting of critical results (Plebani, 2012).

Challenges and Future Directions:

Despite the implementation of various prevention and management strategies, preanalytical errors continue to be a significant challenge in clinical chemistry laboratories. Some of the key challenges include the lack of standardization across different healthcare settings, the increasing complexity of laboratory testing, and the need for continuous quality improvement (Agarwal, 2013; Campana et al., 2011). Future directions in addressing preanalytical errors may include the development of novel technologies for error detection and

prevention, the establishment of international guidelines and best practices, and the integration of preanalytical quality indicators into laboratory accreditation requirements (Codagnone et al., 2014; Llopis et al., 2017). The use of artificial intelligence and machine learning algorithms may also help identify patterns and predict preanalytical errors, enabling proactive interventions (Teshome et al., 2021).

Conclusion:

Preanalytical errors are a major concern in clinical chemistry laboratories, as they can compromise the accuracy and reliability of test results and negatively impact patient care. This narrative review has highlighted the types, frequencies, sources, and impact of preanalytical errors, as well as discussed various prevention and management strategies. Continuous efforts towards standardization, training, quality control, automation, and collaboration are essential for reducing preanalytical errors and ensuring the delivery of high-quality laboratory services. Further research and innovation in this field will be crucial for addressing the ongoing challenges and improving patient outcomes.

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