Journal of Clinical and Basic Research
Online ISSN: 2538-3736

Research Article

Evaluation of Pre-Analytical Errors in Clinical Biochemistry Laboratory of a Tertiary Care Center in India

Kapila Gaikwad[1]*, Sohan Selkar[2]

1 . Department of Biochemistry, Shyam Shah Medical College, REWA, Madhya Pradesh, India
ORCID: 0000-0002-4265-936X
2 . Department of Musculoskeletal Sciences, Datta Meghe College of Physiotherapy, Wanadongri, Nagpur, Maharashtra, India
ORCID: 0000-0002-7959-8994
* **Correspondence:** Dr Kapila Gaikwad, Department of Biochemistry, Shyam Shah Medical College, REWA, Madhya Pradesh, India
Email: drkapila27@gmail.com

Received September 25, 2021 **Accepted** October 27, 2021

ABSTRACT

Background and objectives: Laboratory medicine is equally challenged by economic and new technological pressures. Clinical laboratories have undergone major change due to advancement of technology, which has improved the decision making of clinicians but introduced the risk of errors. This study aimed to evaluate the errors that occurred in the pre-analytical phase of laboratory testing.

Methods: This was a prospective observational study that was done in the Clinical Biochemistry Laboratory of a tertiary care center from June 2016 to May 2017. The path of the sample was analyzed from sample collection to transport. Frequency of deficiencies in the request forms and different types of pre-analytical errors were recorded.

Results: During the study period, the frequency of pre-analytical errors was about 3.1%. Sample hemolysis was the predominant error in sample collected from both indoor and outdoor patients.

Conclusion: Proper management of pre-analytical errors requires continuous evaluation of source of errors, taking corrective measures, and significant interdepartmental cooperation.

Keywords: Preanalytical Errors; Laboratory Errors; Hemolysed Sample; Lipemic Sample; Laboratory Medicine

DOI: 10.29252/Jcbr.5.4.1

Introduction

Efficient laboratory services are the pillars of modern healthcare system. Laboratory medicine is equally challenged by economic and new technological pressures. Clinical laboratories have undergone major change due to technology advancement, which has improved the decision making of clinicians but increased the risk of error at the same time. The laboratory testing process consists of pre-analytical, analytical, and post-analytical phases. According to the International Organization for Standardization (ISO 15189:2012) standard for laboratory accreditation, the pre-analytical phase encompasses all the steps from test request, sample collection, transport, and registration of the sample up to the start of specimen analysis. The analytical phase involves the analysis of the analytes and technical validation of the results. The post-analytical phase includes the interpretation of the results, approval from the lab manager, and reporting (1). Errors can occur in any of these phases. In recent years, there is an increasing awareness of the importance of errors in laboratory practice and their possible negative impact on treatment outcomes.

Advanced instrumentation and automation have simplified the work in the analytical phase but same is not true with regards to the pre-analytical phase (2). This phase is most prone to errors encountered during total diagnostic process, and therefore requires more attention (3-6).

Theoretically, the pre-analytical phase can be subdivided further into pre-pre-analytical phase and conventional phase. In the pre-preanalytical phase, the clinician decides which test is to be ordered based on his knowledge and experience. The conventional phase involves series of processes starting with patient identification, selection of ideal tubes, proper transportation and storage, and preparation of samples (7). The role of human factor in sample collection makes complete elimination of errors impossible. New strategies are followed for error prevention, which can substantially reduce pre-analytical errors. The strategies include increasing the rate of errors detection, certification/accreditation by professional bodies, internal quality control procedures, external quality assessment programs, certification of education programs, and improved communication among health professionals (8).

Pre-analytical errors account for 70% of all mistakes in the clinical laboratory, most of which arise from problems in patient preparation, sample collection, transportation, and preparation for analysis and storage (6,9-11). It has been demonstrated that both pre-analytical and post-analytical errors account for 93% of the total errors encountered in the laboratories (2). This study aimed to evaluate the errors occurring in the pre-analytical phase so that remedial steps can be taken.

MATERIALS AND METHODS

This was a prospective observational study that was done in the Clinical Biochemistry Laboratory of a tertiary care center from June 2016 to May 2017. The tertiary care center consists of the following superspeciality departments: gastroenterology, nephrology, cardiology, cardiovascular and thoracic surgery, neurology, endocrinology, and urology. All routine biochemical tests including blood glucose, renal function tests, liver function tests, lipid profile, phosphorus, uric acid, calcium, urine microprotein, other body fluids electrolytes, and blood gases were performed using the ERBA XL 340 and Trivitron Dirui Autoanalyzer. Serum samples were collected in plain vacutainer tubes having clot activator and gel separator. Plasma was collected in vacutainer fluoride tubes for blood glucose estimation. The laboratory participates in one external quality assurance program. The path of the sample was analyzed.

Outdoor patient department were having computer generated paper with patient's detail and the test requested by the clinician.

The blood withdrawal procedure at the hospital initiated with the patient sitting on a stool, blood withdrawal, and collection into vacutainer tubes. After the samples were labeled manually for name, age, gender, and type of test, the samples were put on separate racks for each unit of laboratory tests. The samples were collected between 8.30 am to 1.30 pm.

All the indoor and outdoor samples were screened for the following pre-analytical errors: 1) Wrong numbering of sample, 2) Delay in sample transport, 3) Sample insufficient, 4) Sample hemolysed, 5) Clotted sample, 6) Sample collection in wrong container, 7) Sample contaminated, 8) Lipemic sample.

The specimens were allowed to clot, centrifuged at a speed of 3000 relative centrifugal force, and then delivered to the analyzers. Thus, the samples were followed from the moment of blood withdrawal to vacutainer transportation, centrifugation of the vacutainers, waiting time, and the time of analysis.

RESULTS

The sum of errors was calculated. Their relative frequencies when compared with the total specimens were also calculated and presented as percentage. In a year period, the total number of outpatients and inpatients was 37054 and 2971, respectively. The following list shows the deficiencies in the requisition form:

1. Patient information (name, age, gender, ward number, registration number)
2. Probable diagnosis
3. Nature of sample (plain/fluoride)
4. Date of sample collection
5. Time of sample collection
6. Signature of person who withdrew the sample Out of the total blood collection tubes screened, pre-analytical errors were observed in 1241 samples (3.1%). The frequency of different types of errors in outdoor and indoor patients is shown in (tables 1 and 2.) Hemolysis was the main pre-analytical error in samples taken from both inpatients and outpatients, which also contributed to the rejection of samples. About 0.05 % of outdoor and 5% of indoor samples was rejected at the pre-analytical phase after centrifugation.

Table 1. The frequency of different pre-analytical errors in outdoor patients

No.	Pre-analytical variables	Number (%)
1	Wrong numbering of sample	11 (0.03%)
2	Delay in sample transport	15 (0.04%)
3	Sample insufficient	6 (0.02%)
4	Sample hemolysed	500 (1.3%)
5	Clotted sample	7 (0.02%)
6	Wrong container	1 (0.002%)
7	Sample contaminated	2 (0.005%)
8	Lipemic sample	3 (0.008%)

Table 2. The frequency of different pre-analytical errors in indoor patients

No.	Pre-analytical variables	Number (%)
1	Wrong numbering of sample	18 (0.6%)
2	Delay in sample transport	15 (0.5%)
3	Sample insufficient	24 (0.8%)
4	Sample hemolysed	604 (20.3%)
5	Clotted sample	10 (0.3%)
6	Wrong container	12 (0.4%)
7	Sample contaminated	8 (0.3%)
8	Lipemic sample	2 (0.07%)

DISCUSSION

According to the International Organization for Standardization, laboratory errors are defined as “failure of planned action to be completed as intended, or use a wrong plan

to achieve an aim, occurring at any part of the laboratory cycle, from ordering examinations to reporting results and appropriately interpreting and reacting to them" (12). Clinicians' decisions mainly rely on laboratory results; hence, laboratory errors must be kept to its minimum. With the advent of technologies, analytical errors have reduced and most errors are related to the pre-analytical phase (13).

In a retrospective study performed by Plebani et al., an Italian stat laboratory was assessed in 1996 and then in 2006. The study showed that about 65.09% of errors occurred in the pre-analytical phase, while about 23.2% and 11.68% of the errors occurred in the analytical and post-analytical phases, respectively (2).

Incomplete laboratory requisition forms may be due to heavy patient load and lack of awareness about the importance of necessary information among the staff involved in blood collection process and transport. Name of the patient, age, gender, registration number, and ward number are important to prevent misplacing of samples. These information can also prevent unnecessary repetition of tests (14). A detail of the probable diagnosis or clinical information helps biochemists to correlate the critical results properly (15). Date and time of sample collection is useful, especially for blood glucose, lipid profile, and thyroid tests. Whether the patient was fasting or not greatly influences the result. If sample for blood glucose is collected in a plain tube with clot activator, glycolysis will lower down the glucose levels by 5-7% per hour, and results will be lower than actual. Moreover, various hormones and body fluids show circadian rhythm. Delay in sample transport from ward to laboratory may also occur due to unavailability of attendants, which also hampers the results (16).

Hemolysis was the most dominant error recorded in both indoor and outdoor samples. Hemolysis is the release of hemoglobin and other intracellular components of erythrocytes into extracellular space of blood (17,18). In vitro hemolysis accounts for more than 95% of hemolytic samples and is mainly linked to sampling and transport procedures. In vivo hemolytic medical conditions are rare (19,20). Hemolysis during phlebotomy may be caused by incorrect needle size, improper tube mixing, excessive suction, prolonged tourniquet, and difficult collection. Therefore, hemolysis starts from the point of venipuncture and continues downstream up to analysis (21-24). Traditionally, hemolysis is detected by visual inspection of blood sample after centrifugation and comparing it with the hemolytic chart. There is always a controversy on whether to accept such samples by hemolysis and report results. This issue is not easy to solve as, whatever the choice is, it can directly affect the management of patients. Hemolysed samples are often rejected, followed by request of recollection. However, repeating sample collection is not always possible. It involves subjecting the patients to an invasive procedure again, which also result in waste of time and resources (21). There is also huge controversy regarding reporting such results amongst laboratory specialists. Some laboratories manage hemolysed samples by reporting the results, but the final result is mathematically adjusted based on estimated degree of hemolysis (25); however, such practice may introduce bias (23). The management of hemolysis remains a dilemma. Improving the communication between clinicians and laboratory specialists may solve the issue to some extent. The patient's status might lead the laboratory specialist to differentiate between in vivo or in vitro hemolysis. There is also a need for emphasis on in vitro hemolysis prevention. Use of appropriate gauze needle for sample collection, placing needle correctly in veins, avoiding sample collection from catheters and lines designed to deliver fluids to the patient, gentle mixing of additives with the specimens, and immediate separation of plasma from cells can help prevent in vitro hemolysis.

Although the laboratory may have

sophisticated analysis facilities, erroneous results cannot be ruled out completely if adequate measures are not taken to prevent contamination of samples from external sources. Some sources of sample contamination are environment, sample container, and sampling tools. Sample collection in appropriate containers is another method of maximizing lab efficiency .The choice between serum and plasma for laboratory tests is often made based on a tradeoff between speed and specimen quality. While serum is considered a cleaner specimen (i.e., free of cells and other interferences), it needs to be clotted for 30 to 60 minutes, depending on the tube used. Rapid clot blood collection tubes with thrombin-based clot activators offer a 5-minute clotting time for serum. This ensures a fast and clean specimen—a “rapid serum”. On the other hand, there is no need to wait for clotting with plasma. The downside of using plasma is interference in tests due to presence of clotting factors, white particulate matter and lower stability lead to decreased glucose levels and increased enzymatic activity over time (26-28).

Serious conditions of hospitalized patients, heavy patient load, and variety of staff involved in the total testing processes may also increase the rate of error. Awareness should be raised amongst residents, interns, physicians, and nursing staff about the importance of providing all the required patient and sample information on the requisition form. Continuing education of phlebotomist, medical staff, and students on the correct blood collection procedure, sample volume, and proper mixing with anticoagulants should be encouraged. Samples should be received and numbered at collection center (15-18). Pre-analytical errors damage an institution’s reputation and impose a significant financial burden on the hospital and laboratory. Although it is not possible to eliminate all pre-analytical errors, compliance with best practices can significantly reduce their incidence (29,30).

CONCLUSION

Continuous evaluation of sources of errors and their corrective measures can help reduce pre-analytical errors. Furthermore, proper management of the pre-analytical errors requires significant interdepartmental cooperation since many error sources fall outside the direct control of laboratory personnel. In this regard, excellent two-way communication between clinicians and laboratory specialists is beneficial.

ACKNOWLEDGEMENTS

None.

DECLARATIONS

Funding

The authors received no financial support for the research, authorship, and/or publication of this article.

Ethics approvals and consent to participate

Not applicable.

Conflict of interest

The authors declare that there is no conflict of interest regarding publication of this article.

REFERENCES

1. Cornes MP, Atherton J, Pourmahram G, Borthwick H, Kyle B, West J, et al. Monitoring and reporting of preanalytical errors in laboratory medicine: the UK situation. Ann Clin Biochem [Internet]. SAGE Publications; 2016 Mar;53(2):279-84 [View at Publisher] [DOI] [PMID] [Google Scholar]

2. Plebani M. Errors in clinical laboratories or errors in laboratory medicine? Clin Chem Lab Med .2006 Jun 1;44(6):750-9 [View at Publisher] [DOI] [PMID] [Google Scholar]

3. Atay A, Demir L, Cuhadar S, Saglam G, Unal H, Aksun S, Arslan B, Ozkan A, Sutcu R. Clinical biochemistry laboratory rejection rates due to various types of preanalytical errors. Biochemia medica. 2014 Oct

15;24(3):376-82. [View at Publisher] [DOI] [PMID] [PMCID] [Google Scholar]

4. Hawkins R. Managing the pre-and post-analytical phases of the total testing process. Annals of laboratory medicine. 2012 Jan 1;32(1):5-16. [View at Publisher] [DOI] [PMID] [PMCID] [Google Scholar]

5. Butterly JR, Horowitz RE. Controversies in laboratory medicine: a series from the institute for quality in laboratory medicine. Medscape General Medicine. 2006;8(1):47. [PubMed] [Google Scholar]

6. Bonini P, Plebani M, Ceriotti F, Rubboli F. Errors in laboratory medicine. Clinical chemistry. 2002 May 1;48(5):691-8. [DOI] [PMID] [Google Scholar]

7. Sharma P. Preanalytical variables and laboratory performance. Indian Journal of Clinical Biochemistry. 2009 Apr;24(2):109. [View at Publisher] [DOI] [PMID] [PMCID] [Google Scholar]

8. Lippi G, Guidi GC. Risk management in the preanalytical phase of laboratory testing. Clin Chem Lab Med, 2007;45:720-7 [DOI] [PMID] [Google Scholar]

9. Lippi G, Chance JJ, Church S, Dazzi P, Fontana R, Giavarina D, Grankvist K, Huisman W, Kouri T, Palicka V, Plebani M. Preanalytical quality improvement: from dream to reality. Clinical chemistry and laboratory medicine. 2011 Jul 1;49(7):1113-26. [View at Publisher] [DOI:10.1515/CCLM.2011.600] [PMID] [Google Scholar]

10. Cornes MP, Atherton J, Pourmahram G, Borthwick H, Kyle B, West J. Monitoring and reporting of preanalytical errors in laboratory medicine: The UK situation. Ann Clin Biochem, 2016; 53(2): 279-284. [View at Publisher] [DOI] [PMID] [Google Scholar]

11. Plebani M. Quality indicators to detect pre-analytical errors in laboratory testing. The Clinical Biochemist Reviews. 2012 Aug;33(3):85 [View at Publisher] [PubMed] [Google Scholar]

12. Medical laboratories - Reduction of error through risk management and continual improvement (ISO/TS 22367:2008, including Cor 1:2009).Published January 2010. Accessed on 21 Nov 2021.

13. Dereen Najat; Prevalence of Pre-Analytical Errors in Clinical Chemistry Diagnostic Labs in Sulaimani City of Iraqi Kurdistan. PLoS One. 2017; 12(1). [View at Publisher] [DOI] [PMID] [PMCID] [Google Scholar]

14. Olayemi E, Asiamah-Broni R. Evaluation of request forms submitted to the haematology laboratory in a Ghanaian tertiary hospital. Pan African Medical Journal. 2011;8(1). [View at Publisher] [DOI] [PMID] [PMCID] [Google Scholar]

15. Ezzelle J, Rodriguez-Chavez IR, Darden JM, Stirewalt M, Kunwar N, Hitchcock R, Walter T, D'souza MP. Guidelines on good clinical laboratory practice: bridging operations between research and clinical research laboratories. Journal of pharmaceutical and biomedical analysis. 2008 Jan 7;46(1):18-29. [View at Publisher] [DOI] [PMID] [PMCID] [Google Scholar]

16. Nutt L, Zemlin AE, Erasmus RT. Incomplete laboratory request forms: the extent and impact on critical results at a tertiary hospital in South Africa. Annals of clinical biochemistry. 2008 Sep;45(5):463-6. [View at Publisher] [DOI] [PMID] [Google Scholar]

17. Lippi G, Blanckaert N, Bonini P, Green S, Kitchen S, Palicka V, et al. Haemolysis: an overview of the leading cause of unsuitable specimens in clinical laboratories. Clin Chem Lab Med. 2008;46(6):764-772.

[View at Publisher] [DOI] [PMID] [Google Scholar]

18. Jeffery J, Sharma A, Ayling RM. Detection of haemolysis and reporting of potassium results in samples from neonates. Annals of clinical biochemistry. 2009 May;46(3):222-5. [View at Publisher] [DOI] [PMID] [Google Scholar]

19. Carraro P, Servidio G, Plebani M. Hemolyzed specimens: a reason for rejection or a clinical challenge?. Clinical chemistry. 2000 Feb 1;46(2):306-8. [DOI] [PMID] [Google Scholar]

20. Cao Y, Branzell I, Vink M. Determination of clinically acceptable cut-offs for hemolysis index: An application of bootstrap method using real-world data. Clinical Biochemistry. 2021 Apr 26. [View at Publisher] [DOI] [PMID] [Google Scholar]

21 . wan Azman WN, Omar J, Koon TS, Ismail TS. Hemolyzed specimens: Major challenge for identifying and rejecting specimens in clinical laboratories. Oman medical journal. 2019 Mar;34(2):94. [View at Publisher] [DOI] [PMID] [PMCID] [Google Scholar]

22. Carraro P, Servidio G, Plebani M. Hemolyzed specimens: a reason for rejection or a clinical challenge?. Clinical chemistry. 2000 Feb 1;46(2):306-8. [DOI] [PMID] [Google Scholar]

23. Simundic AM, Nikolac N, Lippi G. Hemolysis detection and management of hemolyzed specimens. Biochemia Medica. 2010 Jun 4;20(2):154-9. [View at Publisher] [DOI] [Google Scholar]

24. Lippi G, Avanzini P, Pavesi F, Bardi M, Ippolito L, Aloe R, Favaloro EJ. Studies on in vitro hemolysis and utility of corrective formulas for reporting results on hemolyzed specimens. Biochemia medica. 2011 Oct 15;21(3):297-305 [View at Publisher] [DOI] [PMID] [Google Scholar]

25. Vermeer HJ, Steen G, Naus AJ, Goevaerts B, Agricola PT, Schoenmakers CH. Correction of patient results for Beckman Coulter LX-20 assays affected by interference due to hemoglobin, bilirubin or lipids: a practical approach. Clin Chem Lab Med. 2007;45(1):114-119. [View at Publisher] [DOI] [PMID] [Google Scholar]

26. Yu Z, Kastenmüller G, He Y, Belcredi P, Möller G, Prehn C, Mendes J, Wahl S, Roemisch-Margl W, Ceglarek U, Polonikov A. Differences between human plasma and serum metabolite profiles. PloS one. 2011 Jul 8;6(7):e21230. [View at Publisher] [DOI] [PMID] [PMCID] [Google Scholar]

27. Mannello F. Serum or Plasma Samples? The "Cinderella" Role of Blood Collection Procedures Preanalytical Methodological Issues Influence the Release and Activity of Circulating Matrix Metalloproteinases and Their Tissue Inhibitors, Hampering Diagnostic Trueness and Leading to Misinterpretation. Arterioscler Thromb Vasc Biol. 2008;28:611-614. [View at Publisher] [DOI] [PMID] [Google Scholar]

28. Teahan O, Gamble S, Holmes E, Waxman J, Nicholson JK, Bevan C, Keun HC. Impact of analytical bias in metabonomic studies of human blood serum and plasma. Analytical chemistry. 2006 Jul 1;78(13):4307-18. [View at Publisher] [DOI] [PMID] [Google Scholar]

29. Al-Ghaithi H, Pathare A, Al-Mamari S, Villacrucis R, Fawaz N, Alkindi S. Impact of Educational Activities in Reducing Pre-Analytical Laboratory Errors: A quality initiative. Sultan Qaboos University Medical Journal. 2017 Aug;17(3):e309. [DOI] [PMID] [PMCID] [Google Scholar]

30. Chhillar N, Khurana S, Agarwal R, Singh NK; Effect of pre-analytical errors on

quality of laboratory medicine at a neuropsychiatry institute in north India.Indian J Clin Biochem. 2011 Jan;26(1):46-9 [View at Publisher] [DOI] [PMID] [PMCID] [Google Scholar]

How to Cite: GAIKWAD K, SELKAR S. Evaluation of Pre-Analytical Errors in Clinical Biochemistry Laboratory of a Tertiary Care Center in India. Journal of Clinical and Basic Research. 2021; 5 (4) :1-8