Pre-Analytical Errors in Clinical Diagnostic Laboratory: A Crucial Step to Look for Accuracy and Reliability

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Abstract

Clinical Diagnostic Laboratory (CDL) plays a very important role in diagnosis and treatment of diseases. Total testing process (TTP) of laboratory includes pre-analytical, analytical and post-analytical phases. To have an accurate and reliable results, detection and prevention of errors is must from all these phases. Chances of errors are more in pre-analytical phase as compared other two phases. Though standards have been made to control error occurrence in pre-analytical phase, errors still noticed in this phase. The reason is all the steps involved in this phase are dependent on humans and thus it is out of control of laboratory. Therefore it is necessary to generate proper guidelines or manual to minimize errors in pre-analytical phase. This is also an important step to achieve Total Quality Control (TQC). We have tried in this review to summarize important pre-analytical errors, their occurrence at various stages, prevalence and preventive aspects.

Keywords: *Clinical Diagnostic Laboratory, total testing process, pre-analytical errors*

Introduction[1-5]

In current era, disease diagnosis is mostly dependent on accurate and reliable laboratory results. Thus, the role of laboratory became very crucial to ensure the best possible results outcome from its analysis process. Nowadays performance of laboratory drastically improved due to advancement in technology like automation, sample collection, its transport and reports delivery. But it is very difficult, not impossible, to achieve 100% accuracy and reliability in laboratory performance. As it is rightly said that errors are bound to occur in any endeavor, analytical process of lab also faces errors. These errors are classified as pre-analytical (test order to receipt of sample in lab), analytical (sample processing and analysis) and post-analytical (report generation to its dispatch). Out of these three, pre-analytical errors are the most commonly occurred errors in total testing process (TTP) of laboratory. Study showed 46 %-71% errors encountered during TTP were belonging to pre-analytical phase. Hence, this phase must be monitored carefully to avoid such errors. Pre-pre-analytic and actual pre-analytic are two areas of the pre-analytical phase. Selection of Tests to be done, identification of patient for sample collection, preparation and its handling are part of the pre-pre-analytical process. Storage of samples and its processing in lab i.e. pipetting and centrifugation are part of actual pre-analytical process. All the errors occurring before the sample is processed for analysis in laboratory are considered as pre-analytical errors. These include improper test request, fault in sample collection, transportation errors and errors in request forms filling. These all errors are under control of human as it is carried out manually, therefore laboratory have no any control over it. But still all the responsibility lies on the laboratory as finally report is dispatched by lab. Hence,

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laboratory must ensure error-free pre-analytical phase which is a crucial step in quality control (QC) whereby lab maintains its quality.

Pre-Analytical Errors

Pre-analytical errors encompass all the administrative and functional errors that occur prior to laboratory analysis of samples. The International Federation of Clinical Chemistry and Laboratory Medicine (IFCC) have developed the range of pre-analytical phase quality markers to underscore pre-analytical errors. The pre-analytical phase error variables are shown in Table-1.[6-8]

Table-1: Variables of pre-analytical phase

Patient Variables*	Diet, body mass, age, drugs, sex, smoking and tobacco chewing, pregnancy, physical activities, race, dehydration
Collection Variables	Posture, Diurnal variation*, Time of collection, Fasting status, Tourniquet, Presence of IV line, Capillary or Venous, Anticoagulants, Order of draw
Handling Variables	Hemolysed sample, Lipemic sample, Centrifugation phase, Processing time, Temperature, Sun exposure, Evaporation, Aliquoting, Labelling, Transportation

*Uncontrollable variables

List of commonly occurring pre-analytical errors is as below[9]:

- Patient identification error
- Sample labeling error
- Erroneous blood collection or wrong mixture ratio
- Early clotting
- Collection in wrong vacutainer
- Hemolysed sample / lipemic sample
- Increased RBCs and decreased plasma volume
- Effect of temperature/ sunlight
- Lack of timely transportation to lab
- Improper handling of specimen

Patient identification is most important first step in blood sample collection. Error in patient identification is very serious in terms of poor outcome of patient care which can be irreversible. Error in identification may be due to heavy workload experienced by staff in hospital.[10]

Table-2 showed pre-analytical errors observed in previously conducted studies.

Table-2: Pre-analytical errors observed in various studies

Study	Total samples screened	% of Pre-analytical errors observed	Most common pre-analytical error observed	Department from which errors noted maximally (IPD/ OPD)
Bhavsar M et al11	354	41.36	Clot activator or plain tube	IPD

Cont... **Table-2: Pre-analytical errors observed in various studies**

Dahlawi H et al12	2256	3	Clotted blood samples	IPD
Carraro P et al13	17514	61.9	Tube filling error	IPD
Lad H et al14	12680	60	Inappropriate form/ request form filling	IPD
Chhillar N et al15	1536	98	Inappropriate form/ request form filling	IPD
Bhuyar BK et al16	23680	5.20	Hemolysed blood samples	IPD
Gyawali P et al17	5600	26	Inappropriate form/ request form filling	IPD
Chawla R et al1	96328	1.52	Hemolysed blood samples	IPD
Toshniwal P et al18	15320	85	Inappropriate form/ request form filling	OPD
Sushma BJ et al10	19411	3.45	Hemolysed blood samples	IPD

(IPD=Indoor patient department, OPD=Outdoor patient department)

As per the table-2, it can be concluded that

1. the most common pre-analytical errors observed are:

- Hemolysed blood samples
- Clotting blood samples/ tube factor
- Inappropriate form/ request form filling

2. Pre-analytical errors are observed mostly in indoor patient departments (IPD)

Prevention

Pre-analytical errors mostly occurred with the blood specimen followed by urine and other body fluids.[14, 19, 20] The sources of errors with their possible prevention is given in table-3.

Table-3 Sources of pre-analytical errors and its possible prevention (Modified from Neogi SS et al[19])

Phase of pre-analysis	Source of error	Possible prevention
Patient identification Patient preparation	Wrong or incomplete Information on test request form	Use Admission register or ward record Patient identification bands
	Collection after taking food for tests requiring fasting sample	Proper instruction and patient preparation i.e overnight fasting Verify proper preparation before blood collection
	Analytes which can be affected by diurnal variation	Average of the results of two samples drawn at different times of the day
Test request form	Inappropriate form/ request form filling	Training for proper request form filling Sample filled form can be provided
Site of blood collection	Wrong site selected	Choosing the correct site Refer blood collection manual
Site preparation	Contamination with alcohol	After applying alcohol/spirit swab, allow the site of puncture to dry then collect sample Refer blood collection manual
Tourniquet Application and Time	Applied for longer duration	Recommended time for application is less than one minute Refer blood collection manual
Proper Venipuncture Technique	Excessive probing and or fishing	Proper training for phlebotomy Refer blood collection manual
Order of Draw	Incorrect order of draw can lead to potential cross contamination	Order that should be followed: tube for blood culture, citrate tube, serum tube (plain), Heparin, EDTA and fluoride tube Refer blood collection manual
Sample volume and Tube filling	Erroneous phlebotomy technique and tube mixing	All tubes with additives should be mixed evenly with the correct volume of blood as per the request Refer blood collection manual
Tube Handling and Specimen Processing	Erroneous sample handling and processing	To follow guidelines mentioned in blood collection manual
Handling of Blood Specimens in special conditions	Faulty handling	Special training to be given to phlebotomist

For urine specimen, guidelines given by Clinical and Laboratory Standard Institute (CLSI) should be followed.[21] Cerebrospinal fluid (CSF) specimen also forms an important part of CDL. For the collection of CSF, sterile screw-cap tubes should be used. Preferably clinician or resident doctors should collect CSF. Blood contaminated CSF sample must be discarded. CSF sample should be immediately sent to lab after collection. After receiving in lab, it must be centrifuged first before analysis. For preservation, sample should be stored in small aliquot tube to be filled up to 75% to avoid adsorption and evaporation.[22, 23]

Conclusion

The most common errors of pre-analytical phase in clinical laboratory observed are Hemolysed blood samples, mistakes in the filling of tubes or inadequate anticoagulant-blood ratio or tube factor, followed by patient misidentification or improper request form filling. These errors can be prevented by following proper guidelines laid down by various bodies, getting trained in phlebotomy and referring blood collection and other manuals in lab. This forms a very crucial component of laboratory quality**.** Blood collection manual should address not only patient variables but also specimen variables. Training should be provided regarding pre-analytical manual to all the concerned personnel who are part of health care services. Awareness among clinician/ physician regarding such errors and its prevention should be generated which ultimately help in reducing pre-analytical errors.

Search Strategy

We searched Google and PubMed with the terms: "pre-analytical errors", pre-analytical phase", and "biochemistry lab" in combination with "quality control", "total testing process", "clinical chemistry", "laboratory", "analytical phase", "analysis", "clinical biochemistry laboratory". We gave preference to papers published within the past 20 years, but did not exclude some important less recent publications.

Ethical Approval

This study did not warrant institutional review board review as no human subjects were involved.

Source of Funding: Self

Conflict of Interest: None

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