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A STUDY OF PRE-ANALYTICAL ERRORS IN A HOSPITAL BASED CLINICAL BIOCHEMISTRY LABORATORY AND FORMULATION OF MEASURES FOR CORRECTION

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Abstract: A prospective observational study was done in the Central Clinical Laboratory of Gauhati Medical College & Hospital for a period of 2 months from 1st March to 30th April 2014. The objective of the study was to evaluate the pre-analytical phase of laboratory testing in a Clinical Biochemistry Laboratory to detect the different errors which occurred in the preanalytical phase and calculate their percentage and to determine in which step the error occurred so that corrective measures can be formulated to avoid such errors. All the samples and their accompanying laboratory request forms were screened for pre-analytical errors and the daily errors and their types recorded in Problem Notification Logbook. The data collected was analyzed and the entire process of sample collection and transport was evaluated to formulate corrective measures to prevent these errors from occurring. The total number of samples received in 2 months was 23,680. Out of this OPD samples were 11,414 and Indoor samples were 12,266.Of the 12,266 laboratory request forms which were screened 12,106, forms were incomplete i.e. only 160 forms carried all the required information. Out of the total 23,680 sample tubes screened preanalytical errors were observed in 6.61% of Indoor samples and 3.69% of OPD samples. Hemolysed sample was the most commonly observed preanalytical error both in OPD and Indoor samples. Hemolysis was observed in 4.25% of Indoor samples and in 3.55% of OPD samples. Insufficient sample volume was observed in 1.74% of Indoor and .026% of OPD samples. Preanalytical error was observed in 5.20% of samples during the study period. Of this 3.91% of samples received were hemolysed and were rejected .Corrective measures have to be taken to reduce the percentage of rejected samples.

Key Words: Preanalytical error, hemolysis, glycolysis, interference, automation.

INTRODUCTION

Laboratory Medicine plays a vital role in modern day diagnosis and treatment. So it is pertinent that laboratory results which are generated are accurate as patient's health depends on it. The process of clinical laboratory testing comprises of 3 phases. Pre-analytical, Analytical and Post analytical. The pre-analytical phase includes a set of processes that take place from the time a laboratory request is made by a physician until the sample is ready for testing.[1] It comprises of the processes of ordering of test by Physician, request forms filled up, sample collected, sample transported to the laboratory, and lastly sample prepared for analysis. Analytical phase comprises of analysis of samples and generation of reports while in the post-analytical phase laboratory reports are communicated to physicians for proper management of patient.

Errors at any of the phases can have a serious impact on the proper diagnosis and overall health of the patient. With automation of laboratory analysis laboratory errors have significantly decreased, especially those that occur during the analytical phase.70% of total errors within the entire diagnostic process occurs in pre-analytical phase.[1] Various researchers have reported it as 77.1%, 81% and 31.6-75%.[2,3,4] Errors can occur in any of these steps in the Pre-analytical phase and should be evaluated during this phase. However sometimes they are detected in the analytical and post-analytical phases, as seen in case of samples contaminated from infusion route and glycolysed samples.

Though analytical errors have decreased but huge percentage of pre-analytical errors decisively influences the total error and consequently accuracy of test results. This study was conducted with the aim to enumerate the different errors taking place in the pre-analytical phase and their frequency, so that steps can be taken to remove them and guarantee the accuracy of laboratory results generated.

MATERIALS AND METHODS

Gauhati Medical College Hospital is a tertiary care super speciality center. It is a 2185 bed hospital with super speciality departments of Cardiology, Cardiothoracic Surgery, Neurology, Neurosurgery, Gastroenterology, Nephrology, Pediatric Surgery, Urology, Endocrinology and Plastic surgery. A prospective observational study was done in the Biochemistry section of Central Clinical Laboratory (CCL) of GMCH for a period of 2 months from 1st March

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to 30th April 2014. In CCL-Biochemistry, GMCH we have a Vitros 5600 Integrated System, and the tests done are routine biochemical tests, HbA1C, Thyroid profile, PSA and Iron Profile. Samples are collected in clotted vial for all the tests and in EDTA vial for HbA1c.The laboratory participates in 2 External Quality Assurance Programs for evaluation of the analytical phase of laboratory testing. Presuming that errors mainly occur in the pre-analytical phase this study was conducted with the following objectives:

1. To detect the different errors which occurred in the pre-analytical phase and calculate their percentage.
2. To determine in which step the error occurred so that corrective measures can be formulated to avoid such errors and entire process of patient identification, sample collection and transport can be made error free.

All the samples and their accompanying laboratory request forms were screened for pre-analytical errors and the daily errors and their types recorded in Problem Notification Logbook.

Laboratory request forms of indoor samples were screened for :

(1) Patient Information: (a) *Name (b) Age (c) Sex (d) Hospital number (e) Location*
(2) Clinical Information:
(3) Sample Information: (a) *Nature of the sample (b) Date and Time of collection*.

OPD Samples were accompanied by computer generated request forms which carried only patient information and tests request.

All the OPD and Indoor samples were screened for the following pre-analytical variables:

- Wrong / Absent number on samples/missing samples
- Hemolysed Sample.
- Insufficient sample volume.
- Clotted sample in EDTA tube.
- Sample collected in inappropriate container.

RESULTS

The total number of samples received in 2 months was 23,680 Of this OPD samples were 11,414 and Indoor samples were 12,266. Of the 12,266 laboratory request forms which were screened 12,106, forms were incomplete ie. only 160 forms carried all the required information. Table 1 shows the different parameters and their percentage which were absent in the laboratory request forms.

Table 1: Absence of parameters on laboratory request forms

Prefixed criteria	Number	Percentage
Patient information:		
Name	0	0
Age	758	6.18
Gender	754	6.15
Location	233	1.90
Hospital no.	11	.09
Clinical information:	7696	62.74
Sample information :		
Nature of sample	1670	13.61
Date of collection	991	8.08
Time of collection	8605	70.15

Out of the total 23,680 sample tubes screened pre-analytical errors were observed in 1,232 samples i.e 5.20 %.The error percentage was slightly high in the month of March (6.05%) as compared to April (4.25%). This difference in error rate was because of increased number of hemolysed samples received from the OPD in that month. Pre-analytical error was observed in 811 indoor samples (6.61 %) and in 421 OPD samples(3.69%). The total error percentage is shown in table 2 and distribution of different types of error and their percentage are shown in Table 3.

Table 2: Total pre-analytical Errors and their percentage

Data Collection Period	March	April	Total
Number of samples	12,562	11,118	23680
Number of Tests	62,008	54,930	1,16,938
Number of Pre-analytical Errors	760	472	1,232
Percentage of Pre-analytical Errors	6.05	4.25	5.20

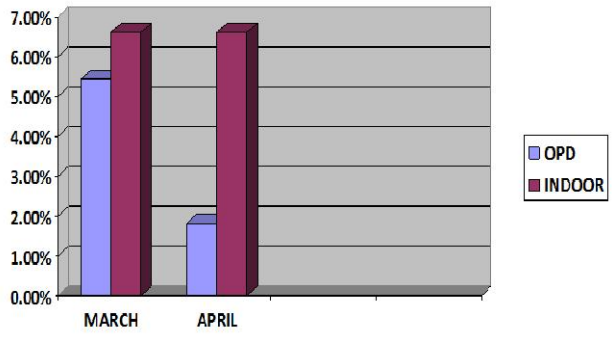

Figure 1: Shows the distribution of pre-analytical errors in the month of March and April in OPD and Indoor samples.

In the month of March total Indoor samples received was 6656 and errors were detected in 440 samples (6.61%). 5906 OPD samples were received and errors were detected in 320 samples (5.42%). In the month of April total indoor samples received was 5610 and errors were detected in 371 samples (6.61%). 5508 OPD samples were received in April and errors in 101 samples were detected (1.83%).

Table 3 : Distribution of Pre-analytical Errors at various levels of sample collection and transport :

	OPD		Indoor	
Total samples	11,414		12,266	
Pre-analytical Error	Number	%	Number	%
Sample collected in inappropriate container	1	.009	6	.05
Delay in sample transport	0	0	22	0.18
Wrong numbering of sample / sample not received	12	0.11	39	0.32
Hemolysed sample	405	3.55	521	4.25
Insufficient volume	3	.026	213	1.74
Clotted sample	0	0	5	.04
Contamination from infusion route	0	0	5	.04
Total Errors	421	3.69	811	6.61

Hemolysed sample was the most commonly observed preanalytical error both in OPD and Indoor samples. Hemolysis was observed in 4.25% of Indoor samples and in 3.55% of OPD samples. Insufficient sample volume was observed in 1.74% of Indoor and .026% of OPD samples.

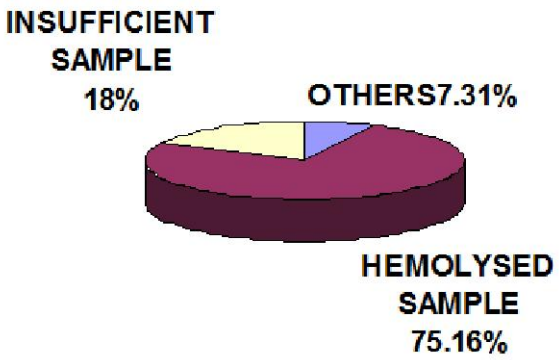

Figure 2: Pie diagram showing distribution of errors

Total errors detected were 1232. The most common error was hemolysed sample. A total of 926 hemolysed samples were received in the 2 months period of study making up 75.16% of the errors. The next commonly encountered error was of insufficient sample volume, which was 17.53%of the errors. Other errors contributed 7.31%, of which sample in inappropriate container was 0.57%, delay in sample transport was 1.79%, wrong numbering and sample not received was 4.14%, clotted sample was 0.41% and contamination from infusion route was 0.41%.

DISCUSSION

Laboratory errors have significantly decreased in the last 4 decades. With advances in technology like automation, analytical errors have decreased considerably and now most of the errors occur in the pre-analytical phase. The magnitude of the effect of these errors on patient care is not negligible since information provided by clinical laboratories affects up to 60-70% of clinical decisions.[1] Therefore it is the duty on the part of the people working in a laboratory to ensure that report generation is prompt and precise.

In this study on examining the laboratory request forms accompanying the indoor samples it was found that 98.70% of forms did not carry all the required information regarding the patient and the sample. Only 1.30% forms carried all the required information. This may be due to excessive patient load and also lack of awareness of the medical staff regarding the importance of the required information in proper processing of samples and dispatch of reports.

The name of the patient was recorded in all the forms whereas their age was not mentioned in 6.18%, sex in 6.15%, hospital number in .09% and location in 1.90% of forms. Recording the age and sex of the patient in the laboratory request form is important for correct interpretation of results, as the reference range of the tests are different for different age groups and sex. These data about the individual characteristics of the patient like age, gender, physiological conditions like pregnancy, menopause, medications, suspected diagnosis are necessary to avoid unnecessary repetition of tests in case of incongruent results that cannot be evaluated due to lack of information. Mentioning the location of the patient helps in correspondence if a fresh sample is required, in case the sample provided is inadequate in terms of either quality or quantity and also for prompt delivery of reports.

Clinical details were not written or ineligible in 62.74% of forms. A brief clinical note accompanying the sample greatly helps the biochemist in reporting results as the biochemist can then correlate any critical results with the clinical note and give correct reports. A similar study done by Nutt et al, reported that the details of diagnosis was not indicated in 19.1% whereas in 80.9% where diagnosis was mentioned, 37.3 % were in abbreviated forms.[5]

As regards to sample details nature of the sample was not mentioned in 13.61% of samples, date in 8.08% and time of sample collection in 70.15% of samples. Failure to mention the nature of the sample had resulted in difficulty in analyzing samples mainly in cases of CSF samples where it is confused with other body fluids. One of the most important detail required in the analysis of a sample is the time when the sample has been collected. This important information for precise reporting was the most neglected. Since most of the samples require glucose test to be done and sample is collected in clot vials, mention of the time becomes even more important. Glycolysis decreases serum glucose by approximately 5% to 7% per hour (5-10 mg/dl/hr) in normal uncentrifuged coagulated blood at RT. Many constituents of body fluids exhibit cyclical or circadian variations. Throughout the day hormones are

secreted in bursts and this fact coupled with the cyclical variation makes proper interpretation of their serum concentration difficult. Serum TSH is at its maximum between 0200 and 0400 hours and its minimum between 1800 and 2200 hours. The variation in amount is about 50%. Plasma insulin is higher in the morning than later in the day, so GTT administered in the afternoon gives a higher glucose value than when the test is done early in the day.[6]

The percentage of glycolysed samples was found to be 0.18%. Glycolysis was suspected when glucose was below the reportable range (<20mg/dl). On enquiry it was found that there was a gap of 4-6 hours between collection of samples and their reaching the laboratory. In some cases samples reached the laboratory the next day of sample collection. This may be because of patient's inability to pay for the test or no attendant available to carry it to the collection centre. The guidelines published by the National Committee for Clinical Laboratory Standards(NCCLS) H5-A3 in 1994 recommend a maximum of 2 hours for transport of blood samples at a temperature range of 10-22°C.[1]

In such samples where considerable time has elapsed between collection and serum separation, other parameters are also affected like potassium (k^+). Glycolysis causes an intracellular shift of k^+ and false low values. The effect is however biphasic, as after the glucose substrate is exhausted k^+ leaks out from the cells and causes a rise in k^+ concentration.[6]

Most pre-analytical errors occur during the sampling process: upto 60% of these errors are attributable to the sample (Lipp *et al.,* 2006a)[7]. A retrospective analysis (2001-2005) of results obtained through the Spanish Society of Clinical Chemistry (SECQ) Quality Assessment Program for the pre analytical phase found that the most common pre-analytical error was "sample not received", followed by "hemolysed samples".[8] In this study screening of both OPD and Indoor samples put forward an error rate of 5.20%, with the indoor samples accounting for a slightly higher 6.61% and OPD samples 3.69%. Hemolysis was the most common error detected both in OPD and Indoor samples. 3.91% of the samples were detected to be hemolysed and were rejected. Hemolysis was slightly higher in Indoor samples (4.25%) as compared to OPD samples (3.55%). In a study by Jay and colleagues the majority of hemolysed samples (>95%) could be attributed to in-vitro processes resulting from incorrect sampling procedure or transport.[9] In OPD systematic blood collection techniques are practiced by trained technicians, but since technician students were engaged for blood collection the percentage of hemolysis was raised in OPD patients. In indoor wards correct procedure is not followed in sample collection and transportation, thereby raising the percentage of hemolysis in Indoor samples. In a similar study conducted in G.B. Pant Hospital, pre-analytical error was observed in 1.9% of Indoor samples, with hemolysis accounting for 1.1% of the errors. The error rate was slightly less in OPD samples, 1.2% and 0.2% of the samples were hemolysed.[10] The external quality control programs for pre-analytical quality organized by CAP have found that hemolysed samples are the most commonly observed errors(Jones *et al.,* 1997).[11]

The next most common pre-analytical error, (0.91%), observed in mainly the Indoor samples (1.74%) was insufficient sample volume. Only 3 OPD sample volumes were inadequate while in case of indoor samples it was 213. Majority of these samples were received from NICU and Pediatric wards. This may be attributed to the fact that it is difficult to collect blood samples in pediatric patients. Lippi and his fellow members reported insufficient specimen quantity and quality accounting for over 60% of pre-analytical errors.[7]

Sample identification error was noted in 0.22% of samples. 12 OPD samples and 39 Indoor samples were either wrongly numbered, not numbered or were not received in the laboratory. This process of receiving and numbering of samples is done manually and due to the heavy load of samples such human errors take place.

A total of seven samples with request for routine biochemistry tests were received in EDTA vials, an inappropriate container in this case as serum or heparinised plasma is the specimen advised to be used in the auto analyzer. Five Indoor samples for HbA1C test was found to be clotted in EDTA vials. This was due to improper mixing of the blood sample with the anticoagulant present in the tube. Five numbers of Indoor samples which were received were suspected to be contaminated from infusion route (i.e. collected from intravenous line). Doubt was raised on analysis of the reports. In all the cases new samples were collected and the tests repeated, the results of which confirmed our doubt.

Interferences in samples was evidenced both in pre analytical process (visual observation of hemolysis, lipemia, high viscosity, bilirubin), analytical (quantification of hemolysis, turbidity, bilirubin), and post analytical phases (aberrant and unexpected results).

The processes that comprise the pre analytical phase of clinical laboratory testing are manually done. Heavy work load and lack of adequate training and

awareness often results in high percentage of errors in this phase.

A knowledge of the scheme of events taking place in the pre analytical phase will help in the analysis of pre analytical errors, its cause and remedial measures.

For Indoor patients:

Step 1: Physicians request for tests.
Step 2: Laboratory request forms written.

Corrective Measure: Awareness should be created among Doctors and Nursing staff regarding the importance of providing all the required information about the patient, clinical state, and sample information.

Step 3: Sample collected.

Corrective Measure: (a) Collection of samples by trained Phlebotomist. (b) Continuing education of Phlebotomist and medical staff and students on the correct procedure of blood collection, correct sample volume, proper mixing with anticoagulants.

Step 4: Sample handed to patient's attendant for payment and transporting the sample to collection centre.

Corrective Measure: (a) Payment for test should be made prior to sample collection. (b) Sample transported by laboratory staff.

Step 5: Sample received and numbered at collection centre.

Corrective Measure: Setting up floor wise collection centres to reduce the load.

Step 6: Sample carried from collection centre to laboratory.

For OPD patients:

Step 1: Physicians request for tests.
Step 2: Payment made.
Step 3: Laboratory request form generated by computer.

Corrective measure: Physician may themselves fill up a requisition form giving all the required details.

Step 4: Sample collected.
Step 5: Sample transported to laboratory.

CONCLUSION

Laboratory medicine plays a very important part in clinical decision making. So it is the duty of the laboratory staff to generate precise reports. Most of the errors in the entire process of laboratory testing is confined to the pre and post analytical phases, which are done manually. Continuous evaluation of the pre analytical phase, the cause of errors and corrective measures should be taken to make this phase error free. Hemolysis is a major factor leading to rejection of samples. Measures taken to reduce hemolysis of samples will increase the efficiency of laboratories. With a knowledge of the hemolysis factor of samples and permissible hemolysis limit for different tests, correction of test results for the amount of hemolysis present in the sample will reduce the percentage of rejected samples. Co-operation is required from other medical departments in providing correct information regarding the patient and the sample, for proper running of tests and interpretation of results.

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