Role of Nursing Personnel in Laboratory Testing

Rateesh Sareen[1]*, Akanksha Dutt[2]

[1]Consultant Pathology, SDM Hospital, Jaipur, India

[2]Consultant Anesthesiology, Khandaka Hospital, Jaipur, India

Abstract

In modern medicine, doctors rely heavily on diagnostic testing to assist them with patient management, making or excluding diagnosis and implementing an appropriate treatment plan. It is therefore important that the laboratory produces quality test results. As laboratory testing errors mainly occur outside the analytical process, they are likely to span the current branches or subspecialties of laboratory medicine, including clinical biochemistry, hematology, coagulation, immunometric and molecular biology. Inappropriateness of the samples especially due to blood drawing errors generally occurs when the blood samples are drawn by nurses whose experiences and training are not sufficient for blood drawing in clinics comparing to the phlebotomists who are a group of more stable staff. Inappropriate laboratory utilization ultimately increases healthcare costs, harms patients and perpetuates the vision of laboratory testing as a commodity. The paper highlights the various factors affecting laboratory results some that can be controlled by training and learning while others that arise out of biological variations thus non modifiable.

Keywords: Preanalytical errors; Nursing training; Phlebotomy

Introduction

The advancement in instrument technology, automation and manpower skills have simplified the laboratory testing. The laboratory testing of any analytic comprises of three phases namely - Preanalytical, Analytical and Post analytical phases. The preanalytical errors are the errors that occur from the time a laboratory test is ordered by the clinician until the sample is ready for analysis. This stage of laboratory testing is most prone to errors with 46-71% errors encountered during the testing process [1,2]. The preanalytical phase involves people beyond the limits of laboratory and in hospitals/clinics the nursing personnel are often entrusted with the responsibility of collecting blood samples from the patients and sending them to the laboratory for analysis. The nursing staff need not be expert in technical details of laboratory analysis but awareness of common preanalytical variables is favorable as their knowledge has significant effect on sample collection process and subsequently the laboratory test results. Insufficient quantity and inappropriate quality of specimen may account for over 60% of preanalytical errors [3]. The lack of understanding of blood collection process [4], errors in patient identification and preparation [5], defect in sample collection device/container [6] and error in sample handling ultimately compromise laboratory results. These errors can seriously affect reliability of test result and affect patient care adversely. As the sample collection is performed by nursing staff these errors can rarely be identified by the laboratory. The role of 'human factor' in sample collection makes the elimination of errors unrealistic but awareness and identification of areas of possible error with adequate, repetitive, continual professional training can significantly reduce them [7]. The purpose of this article is to highlight the common variables and to enlighten the nursing staff of common pre analytical variables that affect test results. The common variables pertaining to samples of blood are elucidated in the following paragraphs (Table 1).

Identification of patient: It is of utmost importance to identify correct patient so as to collect the correct sample. Whenever identification of patient is done it is always prudent to use two identifiers like name of the patient & unique identification number with date of birth[8] and the in house patients should wear wrist bands with the above identification information which is verified by the staff time and again the samples are collected from the patient [8]. Identification of critically ill, comatose patients or children should be carried out with extra precaution by adopting stringent vigilant methodology to ensure that there is no error as any lax attitude could not only result in wrong sampling but also unreliable laboratory result ultimately affecting patient care and in unfortunate cases an error in judgment inviting medical negligence [9].

Container labeling: Incorrect labeling of sample will inadvertently have incorrect laboratory

Table 1: Common errors in sample collection and their consequences.

| Error	Consequences
Patient identification	Misdiagnosis, Delayed diagnosis
Patient preparation	
Diurnal variation	Falsely low or high values
Collection after meal in place of fasting	Altered glucose & lipid profile
Site of blood collection	ABG analysis altered
Tourniquet application	Prolonged application cause falsely high calcium level, excessive probing can cause hemolysis.
Order of draw	Falsely elevated potassium level
Specimen volume	Altered Prothrombin time
Handling of specimen	Unstable samples poor handling result in ACTH, ACE level alteration

Table 2: Effect of biological variables.

Variable	Increase	Decrease
Fasting	Amino acids, Fatty acids, Ketone, Lactate, Bilirubin, Growth Hormone, Glucagon, Triglyceride	Glucose, HDL, Lactate dehydrogenase, Insulin
Exercise	AST, Bilirubin, Creatine kinase, HDL, Lactate, LDH, Uric acid	

result. The staff should abide with correct sample labeling techniques with labeling of tubes done immediately after sample collection at bedside as enshrined in The Clinical & Laboratory Standards Institute (CLSI) guidelines [10].

Specimen discrepancy: Specimen discrepancy or inconsistency can be a labeling error (requisition, container/ vacutainer or both); lack of mention of anatomical site in surgical pathology samples; discordance in requisition form verse container; incomplete clinical information on form; specimen designation not clearly mentioned or improperly prepared specimen prior to arrival in the laboratory. The severity of discrepancy will determine the degree to which the patient can be affected. These errors are particularly more common in surgical pathology and quick identification is needed to abate potential harm to patients. The nursing staff working in operation theatres and surgical areas handling tissue specimens should be aware of the effects of mislabeling of the containers and inappropriately filled forms in particular. The lack of information on the requisition form prevents laboratory from further processing the samples ultimately delaying diagnosis and patient care. Labeling errors are generally of three types [11]. Firstly, an unlabeled container or requisition arriving in surgical pathology meaning that the container or requisition form may lack proper patient identification. Second type of errors can be like the container is identified as one patient while the accompanying requisition states a different patient. Third type, the cruelest one involves, a labeled requisition and container with the same patient identified but it is the wrong patient. This error could only be recognized by the individual who was responsible for it independent of laboratory intervention. The only way to minimize labeling errors is to implement a 'double check system' before specimens' leave clinical setting implemented by clinical staff including nursing staff. There should be an appointed member of the clinical staff to recheck each specimen in the area to ensure accuracy. A log sheet bearing initial of both staff members should be recorded for tracking purpose. 'To err is human', but the only way to overcome these errors is by communication, education and collaboration [12].

Patient preparation: The collection of clinical chemistry samples for fasting glucose estimation and lipid profile requires overnight fasting (at least 12 hours), these considerations must be given by the nursing staff while collecting blood samples.
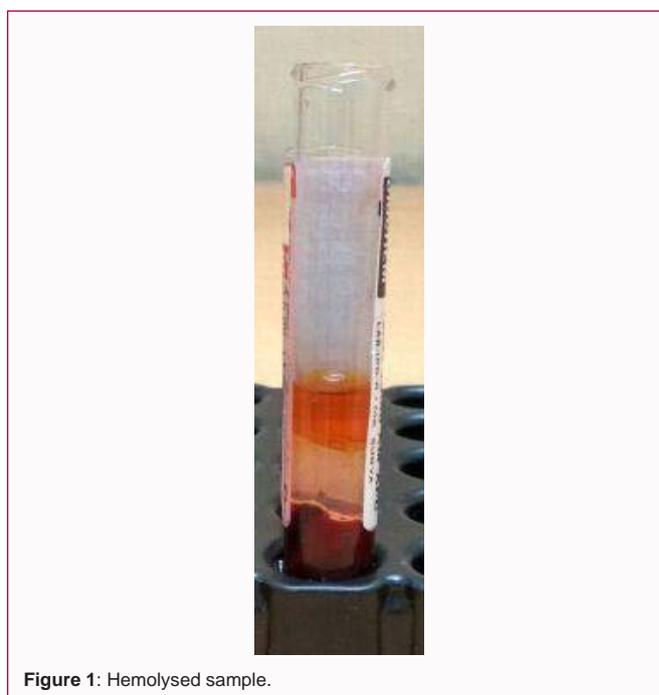
Figure 1: Hemolysed sample.

Site selection: The site of venipuncture can compromise the quality of sample. The most commonly selected site is the median cubital vein followed by cephalic vein and lastly the basilica vein. Sampling from basilica vein should be done with caution as there is risk of damage to the neighboring brachial artery and median nerve. The venipuncture site should be cleaned with alcohol beginning with the center of site and continuing outwards in concentric circles. Alcohol should be allowed to air dry before starting venipuncture as contamination with alcohol can lead to hemolysis resulting in spurious elevations of levels of analytic such as potassium, Lactate Dehydrogenase (LDH) and magnesium (Figure 1,2).

Tourniquet: The tourniquet should be applied 3-4 inches above the venipuncture site. It creates an increase in pressure below the site of application resulting in increase in concentration of protein bound non diffusible analyte [13,14]. It is generally accepted that tourniquet should not be kept for more than one minute. renowned and colleagues

demonstrated maximum changes in analyte concentration occurred at the time of tourniquet release and therefore recommended that samples be collected when tourniquet was in place or at least 1 minute after its release [15]. The national committee for clinical laboratory standards guideline for blood specimen collection states that the tourniquet should be released as soon as blood flow is established to minimize the time the tourniquet is in place [16]. Each institute should determine a standard approach to be used for all collections. It is recommended to minimize occlusion time and avoidance of pumping of fist. Prolonged tourniquet application causes changes in concentration of analyte like total protein, calcium, alanine aminotransferase, aspartate aminotransferase, creatinine kinas, bilirubin and protein [17]. The person drawing the blood should not probe to find vein as it causes hemolysis and poor quality of samples.

Order of draw: The order of draw as recommended by CLSI for evaluation blood collection tubes: tube for blood culture, citrate tube, serum separator/serum tube, heparin, ethylenediamine tetra acetic acid and fluoride tube8. The contamination of K2 or K3 EDTA on the needle from the lavender top tube to chemistry tube can lead to high serum potassium level.

Tube mixing: Tubes containing additives should be mixed by inverting tubes at least 8-10 times for proper uniform mixing of anticoagulant with patient blood. They should not be shaken vigorously as it might cause hemolysis. The vacutainers should not be expired before use as it may cause loss of vacuum resulting in inappropriately volume and changes in blood to additive ratio [18,19].

Time of sampling: There are number of analyte that have shown circadian rhythm of their plasma concentration during 24 hour period in response to meals, sleep, posture and stress changes. Serial collection at similar times of the day will minimize differences due to diurnal variations. The timing of collection is crucial especially for drugs in the therapeutic window are small. Such examples include like concentration of potassium is lower in afternoon than in the beginning of the day and for cortisol it is vice versa [20]. For infections where shedding is irregular timing of sampling is crucial. Say for instance shedding precedes fever and chills by up to 1 hour. In such case, temperature curve or fever pattern of the particular patient may permit prediction of new spike and blood sampling time can be adjusted so that culture sample is collected at the time of maximum probability of detecting the infectious agent.

Working in senses: Nursing staff should be vigilant especially during sample collection and should not work mechanically rather with an alert inquisitive mind. Serum separator tubes might be unacceptable for some analytes [21,22] therefore they mandate disclosure by manufacturer. If possible in house studies should be done to demonstrate suitability of gel containing collection tubes for analytes that are not evaluate by tube manufacturers.

Intravenous Infusions

The collection of blood samples from ongoing Intravenous (IV) infusion is highly problematic. It is best to collect the sample from alternative site or by capillary puncture. In cases where alternative site is not available and sample needs to be collected from the arm having IV infusion it is recommended to first turn off the IV infusion for minimum of 2 minutes then apply tourniquet and then collect blood sample from vein below the IV site. The interference from dilution by IV fluid can be minimized if 5 ml of blood is discarded before collection.

Figure 2: Lipidemic sample.

Delay in Transport and Processing

All samples should be processed promptly after collection as allowing cells to remain in contact with the plasma or serum can cause increase in concentration of some analytes like Creatine kinase, lactate, LDH, Ammonia and phosphate. Glucose, bicarbonate and acid phosphate concentration may decrease on standing. Acid base analysis samples from arterial line need to be sent immediately as soon as possible to the laboratory at lower temperatures, similarly sample for platelet functional analysis needs to be sent immediately without shaking else the result quality will be compromised. Both the above mentioned special requirements of transport of samples should be taught and put in to practice by nursing or personnel collecting blood samples. Samples in glass tubes take 20-30 minutes for clotting whereas it takes slightly longer time for samples in plastic tube. The tube should be held upright and as a general rule plasma separation should be done within 1 hour of collection and serum separation in 2 hours of collection. The centrifugation time and speed should be in compliance with manufacturer recommendation.

Temperature

The nursing staff is entrusted with the responsibility of transport of specimen at the desired temperature. Analyte like ammonia, blood gas, acid phosphatase, lactate, pyruvate, gastrin and parathyroid hormones are temperature labile and need stringent conditions of transport [23]. A brief knowledge of preanalytical errors by nursing staff helps in understanding rationale behind collection and processing requirements to ensure that right specimen in drawn by right person in right manner under right set of conditions, transported at right time to laboratory.

Biological Factors

Apart from above mentioned factors there are long term biological variables that cannot be supervised accurately but at the same it is important to be aware of them as they affect laboratory results (Table 2). These variables include age, gender, race, effect

of menstrual cycle, pregnancy, diet, exercise, alcohol intake, use of caffeine, smoking and postural changes [24]. The newborn have increased hemoglobin concentration, they have low blood glucose levels due to small glycogen reserves. The serum creatinine concentration rises from infancy to puberty depending on skeletal muscle development [25]. The alkaline phosphatase activity is greater in males than in females and vice versa when females reach over 50 years of age [26]. Gender specific hormones are different and gender based differences are observed in albumin, calcium, magnesium and hemoglobin levels (lower in females) whereas amino acids, urea, uric acid, Creatinine, Reticulocyte count aspartate aminotransferase, alanine aminotransferase, alkaline phosphatase and creatine kinase (higher in males) [24,27]. The plasma concentration of cholesterol, total protein, albumin, fibrinogen, serum calcium-phosphate and iron as well as female sex hormones are affected by menstrual cycle and pregnancy which results in hemodilution. Diet charts are maintained for in house patients in hospitals. They provide a ready reference to all solid and liquid intakes by patients. Any special requirement in diet that the patient is receiving should be mentioned in test requisition form by either the nursing staff or by the duty doctor so that laboratory can interpret results in a meaningful manner. A high fat meal causes increase in serum concentration of glucose, iron, lipids, alkaline phosphatase and triglycerides whereas it reduces serum urate levels [28]. A higher protein diet intake increases plasma urea, serum cholesterol and phosphate concentration. Short term starvation (48 hours) leads to significant changes including increased organic acids like ketone bodies (aceto acetic acid, beta hydroxyl butyric acid) which causes metabolic acidosis with a decrease of both PH and bicarbonates [29]. Long term starvation leads to decreased concentration of blood proteins, cholesterol, triglycerides, apolipoproteins and urea [30]. Exercise and physical activity causes changes in concentration of analyte due to volume shifts between intravascular and interstitial compartments, loss of volume by sweating and changes in hormone concentration of epinephrine, norepinephrine, glucagon, somatotropin, cortsol, ACTH (increased) and insulin (decreased) [31,32]. There are studies in literature that have demonstrated rise of creatine kinase four times, pyruvate kinase 2.6 times, AST & bilirubin 1.4 times and urea 1.3 times in samples from individuals tested a day before and 45 minutes after marathon race [33]. The intake of beverages like coffee, tea and soft drinks also affect analyte concentration due to caffeine content which is found to inhibit phosphodiesterase and subsequently cyclic AMP degradation. Cyclic AMP rises blood glucose concentration and plasma renin activity and catecholamine release [34]. Smoking entails changes in blood leukocytes and erythrocytes, vitamins, tumor markers and heavy metals [35]. Nursing staff needs to pay extra attention to patient's posture while drawing samples for catecholamines, aldosterone, rennin, angiotensin II and anti-diuretic hormone analysis [36], because supine position tends to reduce effective filtration process causing volume shift from intravascular compartment. In upright condition macromolecules with greater than 4 nm diameter cannot pass through the membrane and follow volume shift leading to increased concentration of measured analyte by 5-15% in comparison to supine position.

Conclusion

Diagnostic investigations are the back bone of patient care as clinical decisions heavily rely on the performance and interpretation. The advent of modern instruments in laboratory medicine has made investigations more perfect but it is crucial to be aware of factors affecting results. Nursing staff, phlebotomist, junior doctors, consultants, laboratory staff and pathologist all must act in tandem as their collaborative team effort can ensure best patient care.

References

1. Plebani M. Errors in clinical laboratories or errors in laboratory medicine? Clin Chem Lab Med. 2006;44(6):750-9.

2. Atay A, Demir L, Cuhadar S, Saglam G, Unal H, Aksun S, et al. Clinical biochemistry laboratory rejection rates due to various types of preanalytical errors. Biochem Med. 2014;24(3):376-82.

3. Lippi G, Bassi A, Brocco G, Montagnana M, Salvagno GL, Guidi GC. Preanalytic error tracking in a laboratory medicine department: Results of a1year experience. Clin Chem. 2006;52(7):1442-3.

4. Li ppi G, Sal vagno GL, Mont agnana M, Franchini M, Guidi GC. Phlebotomy issues and quality improvement in results of laboratory testing. Clin Lab. 2006;52(5-6):217-30.

5. Bologna LJ, Lind C, Riggs RC. Reducing major identification errors within a deployed phlebotomy process. Clin Leadersh Manag Rev. 2002;16(1):22-6.

6. Bologna LJ, Mutter M. Life after phlebotomy deployment: Reducing major patient and specimen identification errors. J Healthc Inf Manag. 2002;16(1):65-70.

7. Lippi G, Guidi GC. Risk management in the preanalytical phase of laboratory testing. Clin Chem Lab Med. 2007;45(6):720-7.

8. Er nst DJ, Bal ance LO, Cal am RR, Rut h McCall, Smith SS, Szamosi DI, et al. Clinical Laboratory Standards Institute (CLSI). Procedures for the collection of diagnostic blood specimens by venipuncture; approved standard.

9. Kornstein MJ, Byrne SP. The Medicolegal Aspect of Error in Pathology: A Search of Jury Verdicts and Settlements. Archives of Pathology & Laboratory Medicine; 2007;131(4):615-8.

10. Procedures for the collection of diagnostic blood specimens by venipuncture; Approved Standard. 6th ed.

11. College of american pathologists commission on laboratory accreditation. Laboratory Accreditation Program. Laboratory General Checklist. College of American Pathologists. 2006.

12. Kohn LT, Corrigan JM, Donaldson MS. To err is Human: Building a Safer Health System. Washington, DC: National Academy Press; 2000.

13. Tan MH, Wilmhurst EG, Gleason RE, Soeldner JS. Effect of posture on serum lipids. N Engl J Med. 1973;289(8):416-9.

14. Recommendations for improving cholesterol measurement: A report/ from the laboratory standardization panel of the national cholesterol education program. Bethesda, Md: US Dept of Health and Human Services, Public Health Service, National Institutes of Health; 1990.90-146.

15. Renoe BW, McDonald JM, Ladenson JH. The efforts of stasis with and without exercise on free calcium, various cations and related parameters. Clin Chim Acta. 1980;103:91-100.

16. National Committee for Clinical Laboratory Standards. Standard Procedures for the Collection of Diagnostic Blood Specimens by Venipuncture. Approved standard. ASH-3. Villanova, Pa: National Committee for Clinical Laboratory Standards; 1977.

17. Statland BE, Bokelund H, Winkel P. Factors contributing to intra-individual variation of serum constituents: 4. effects of posture and tourniquet application on variation of serum constituents in healthy subjects. Clin Chem. 1974;20(12):1513-19.

18. NCCLS-Tubes and Additives for Venous Blood Specimen Collection; Approved Standard- 5th Edition. H1-A5 23(33);2003.

19. BD Evacuated Blood Collection System Package Insert 6/2004.

20. Touitou Y, Haus E. Biologic rhythms in clinical and laboratory medicine. Berlin, Heidelberg, New York: Springer Verlag. 1992.

21. Dasgupta A, Dean R, Saldana S, Kinnaman G, Mclawhon RW. Absorption of therapeutic drugs by barrier gels in serum separator blood collection tubes. Volume-and time-dependent reduction in total and free drug concentrations. Am J Clin Pathol. 1994;101(4):456-61.

22. Mole L, Margolis D, Carroll R, Todd J, Holodniy M. Stabilities of quantitative plasma culture for human immunodeficiency virus, RNA, and p24 antigen from samples collected in VACUTAINER CPT and standard VACUTAINER tubes. J Clin Microbiol. 1994;32(9):2212-5.

23. Young DS. Effects of preanalytical variables on clinical laboratory tests. Washington, DC: AACC Press. 2nd ed. 1997.

24. Young DS, Bermes EW. Specimen collection and processing: sources of biological variation. In: Tietz NW, ed. 3rd ed. Textbook of clinical chemistry. Philadelphia: WB Saunders Company; 1987:58-101.

25. Calam RR. Samples from Patients to Laboratories. Walter Guder, Sheshadri Narayanan, Hermann Wisser, Bernd Zawta. Darmstadt: Git Verlag. Clinical Chemistry. 1996;43(8):1470a-1.

26. Schiele F, Henny J, Hitz J, Petitclerc C, Gueguen R, Siest G. Total bone and liver alkaline phosphatases in plasma: biological variations and reference limits. Clin Chem. 1983;29(4):634-41.

27. Tarallo P, Humbert JC, Mahassen P, Fournier B, Henny J. Reticulocytes: Biological variations and reference limits. Eur J Haematol. 1994;53:11-5.

28. Rifai N, Merrill JR, Holly RG. Postprandial effect of a high fat meal on plasma lipid, lipoprotein, cholesterol and apolipoprotein measurement. Ann Clin Biochem. 1990;27:489-93.

29. Lamers KJ, Doesburg WH, Gabreëls FJ, Lemmens WA, Romsom AC, Wevers RA, et al. The concentration of blood components related to fuel metabolism during prolonged fasting in children. Clin Chim Acta. 1985;152(1-2):155-63.

30. Ditschuneit H, Wechsler J. Probleme der ambulanten nulldiätbehandlung. Dtsch Arztebl. 1979;76(13):871-80.

31. Alexander S. Physiologic and biochemical effects of exercise. Clin Biochem. 1984;17(2):126-31.

32. Cumming DC. Hormones and athletic performance. In: Felig P, Baxter JD, Frohman LA, eds. 12 Endocrinology and metabolism. New York, Toronto: McGraw- Hill, 1995:1837-85.

33. Stansbie D, Begley JP. Biochemical consequence of exercise. J IFCC 1991;3:87- 91.

34. Robertson D, Frölich JC, Carr RK, Watson JT, Hollifield JW, Shand DG, et al. Effects of caffeine on plasma renin activity, catecholamines and blood pressure. N Engl J Med. 1978;298(4):181-6.

35. Young DS. Effects of preanalytical variables on clinical laboratory tests. Washington, DC: AACC Press; 1993.

36. Felding P, Tryding N, Petersen PH, Horder M. Effects of posture on concentrations of blood constituents in healthy adults: practical application of blood specimen collection procedures recommended by the Scandinavian Committee on Reference Values. Scand J Clin Lab Invest. 1980;40(7):615-21.