EUROPEAN JOURNAL OF BIOMEDICAL AND PHARMACEUTICAL SCIENCES
http://www.ejbps.com

ISSN 2349-8870
Volume: 12
Issue: 3
Year: 2025

VERIFICATION OF LABORATORY BLOOD COLLECTION TUBES

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Article Received on 21/01/2025 **Article Revised on 10/02/2025** **Article Accepted on 02/03/2025**

ABSTRACT
The selection and procurement of blood collection tubes in healthcare facilities is often underestimated issue, due to different factors including the lack of knowledge about the importance of preanalytical quality and phlebotomy processes. Validation is the process of conducting studies to prove that the device or system meets the requirements of its intended use, to be fulfilled by the manufacturer. Verification is a similar process to validation but typically involves less vigorous studies that the customer uses to show the manufacturer performance claims are met satisfactorily in their testing environment. The aim of this study was to assess the performance verification of biochemistry serum collection tubes in our routine testing environment before putting into use

KEYWORDS: Validation, Verification, Preanalytical errors.

INTRODUCTION

Reliable and accurate laboratory test reporting is crucial for treating the patients.[1] The quality of the reported test results is directly linked to the quality of the specimen, Unsuitable sample specimen can impact the accuracy of the Reported results. [2] Error may occur in the preanalytical, analytical, and post analytical phases of testing Technological advances have reduced the errors within the analytical and post analytical phases[3] Control of errors within the pre- analytical phase often is difficult as the pre-analytical phase involves non-laboratory personnel and also escapes quality control and proficiency testing programmes.[3,4,] Preanalytical variability plays a crucial role in laboratory diagnostics,[5] Most of the errors occur in the preanalytical phases related to collection and management of biological samples.[6] The use of high-quality serum collection tubes is important in routine laboratory practice, where in appropriate serum collection tubes may be a source of preanalytical bias which can impact the reported results.[7] An important preanalytical considerations is that serum collection tubes are important sources of laboratory variability,[8,9] Thus a well-defined verification studies are required prior to the use of new brands of serum collection tubes.[10] The design for serum collection tubes verification studies should include all possible regulatory requirements, an appropriate number of samples distributed across the analytical range of assays performed in the particular.

TECHNICAL VERIFICATION

Prior to blood sample collection the control tubes are assessed for Ease of use, Physical defects, assembly proper\improper, safety aspects, vacuum defects, Improper filling, under filling, Leakage, Tube needle holder contamination, Hemolysis, Tube broken or spill after centrifugation, Serum separation proper\improper, clotting adequate\inadequate, Acceptable difference is calculated as Difference = No. of comparative tubes/120X100 – No of Control tubes / 120 X 100 Acceptable criteria are < 1.0 %.

CLINICAL VERIFICATION

All reagents, controls, QC materials were stored and handled as per standard operating procedures and

manufacturers specifications, Serum tube were assessed for comparative and control tubes for Glucose, urea, creatinine, calcium, Phosphorous, Cholesterol, Triglycerides, AST, ALT, ALP, in fully automated Cobas Integra 400 plus analyzer,. Statistical analysis of 'R' value calculation using regression analysis, carried out with acceptable criteria, % of bias calculated for all parameters with CLSI guidelines 2025. Lab settings and environment to be decided by the appropriate statical power for the study to be used in the verification studies, overall the design of the study should include all aspects of technical & clinical verification before a new set of serum collection tubes are put into use.

MATERIALS AND METHODS

Serum collection tubes verification study was performed to assess technical and clinical aspects of serum tubes for biochemical investigations during June 2023 to August 2023 in Department of Laboratory Medicine, Dr. Mehta's Multispeciality Hospital Pvt Ltd Chennai Tamilnadu India. With proper consent and ethical approval.

The European Federation of Clinical Chemistry and Laboratory Medicine Working for Preanalytical Phase (EFLM WG-PRE) recommends that a laboratory performs a local validation of all new serum collection tubes (control tubes) estimating the potential bias and imprecision of the test results compared to previously used material (comparative tube) to verify the manufacturer claims. This approach is carried in number of studies in all diagnostic testing[11-14] including molecular biology.[15,16] Blood was collected by trained phlebotomist from the routine patients with proper consent 20 paired blood samples collected from Median cubital vein into comparative and control tubes.

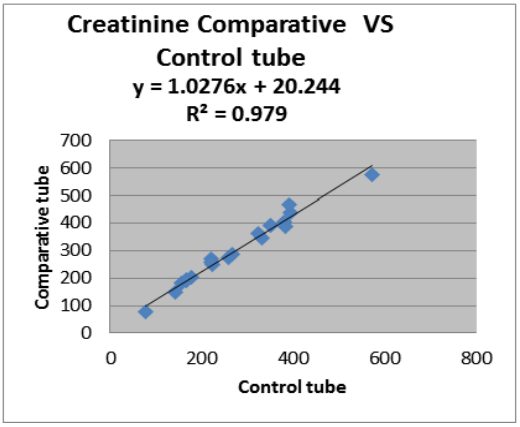
RESULTS

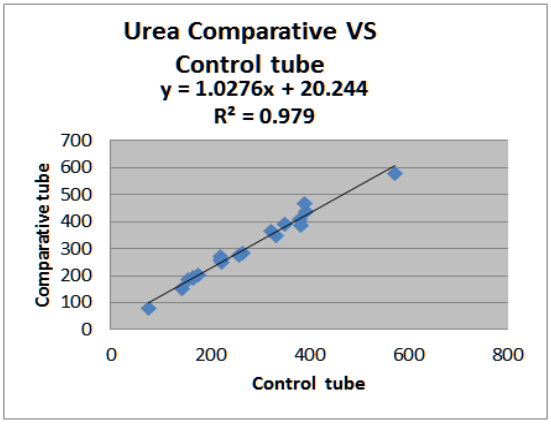
No major defects observed during phlebotomy and serum separation process in the essential requisites for Technical verification of serum collection tubes, (Table 1) however we observed slight changes in the vacuum defects, improper filling, hemolysis, and improper serum separation (1 tube out of 20 tubes) but the variation was well within the acceptable criteria of < 1%, Inadequate clotting observed in 2 tubes out of 20 tubes with % of difference of 1.6%, (Both dialysis patients).

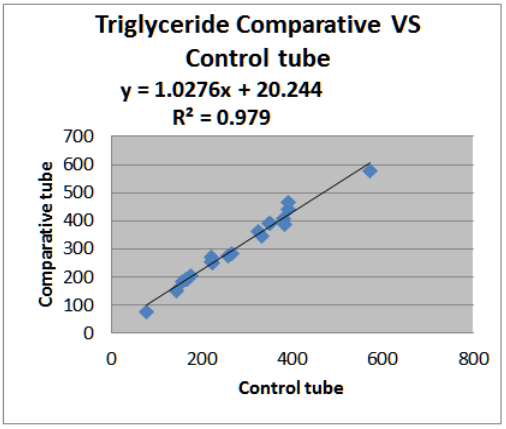
Table 1: Technical aspect of serum collection tubes for verification.

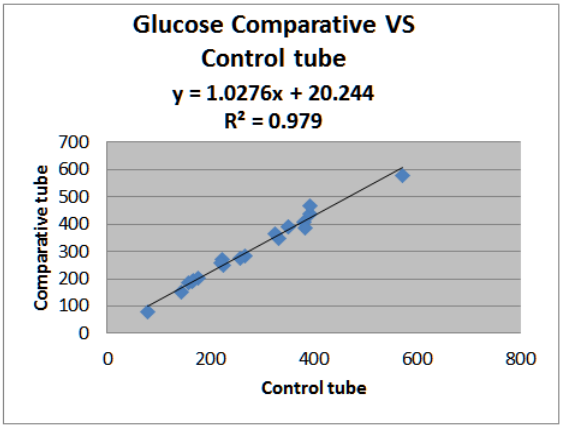
S. No	Essential requisites for serum collection tubes	No of control tubes verified	No of control tubes accepted	Acceptable difference <1%
1	Ease of use	20	20	No difference
2	Physical defects	20	20	No difference
3	Assembly proper/improper	20	20	No difference
4	Safety aspectss	20	20	No difference
5	Vacuum defects	20	19	0.8%
6	Improper filling	20	20	No difference
7	Under filling	20	20	No difference
8	Leakage	20	20	No difference
9	Tube needle holder contamination	20	20	No difference
10	Haemolysis	20	19	0.8%
11	Tubes broken as spill after centrifugation	20	20	No difference
12	Serum separation proper/Improper	20	19	0.8%
13	Clotting adequate /In adequate	20	18	1.6%

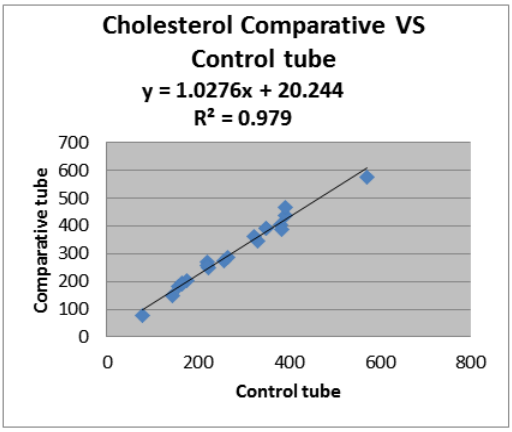
In Clinical verification 'R^2' values of regression analysis for all biochemical parameters were within acceptable range, % of bias for parameters verified were within acceptable range in comparison with CLSI guidelines.2025. Table 2.

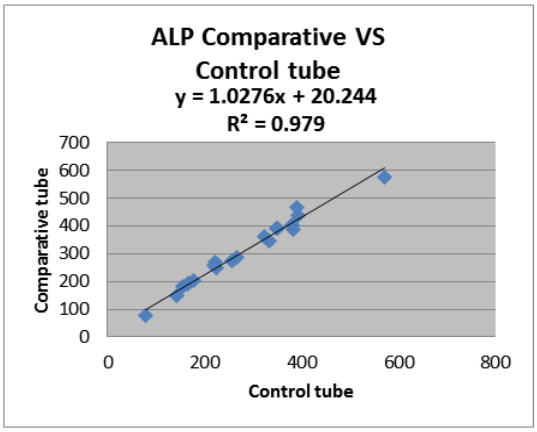


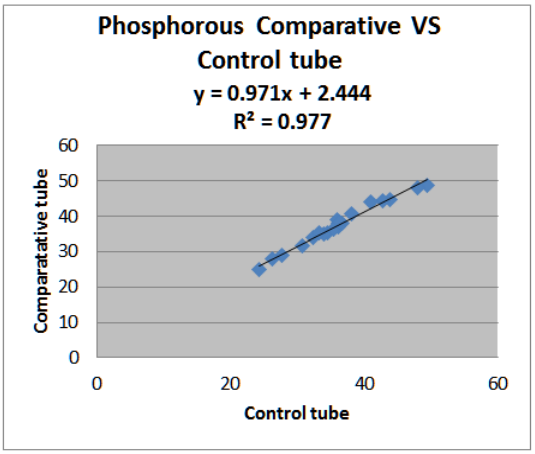


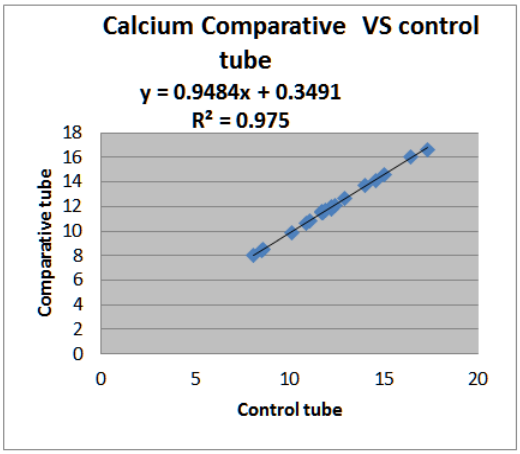

Triglyceride Comparative VS Control tube
y = 1.0276x + 20.244
R² = 0.979
Comparative tube
Control tube
0
100
200
300
400
500
600
700
0
200
400
600
800

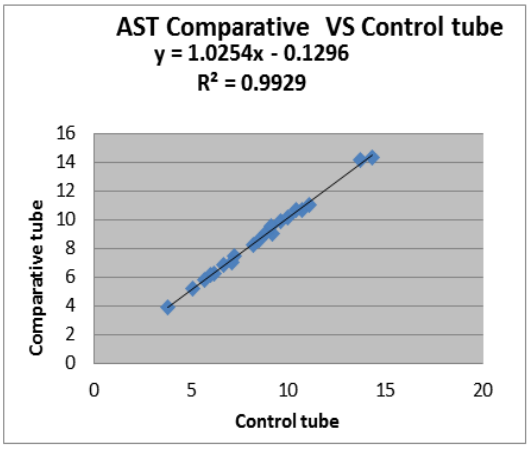

Glucose Comparative VS Control tube
y = 1.0276x + 20.244
R² = 0.979
Comparative tube
Control tube
0
100
200
300
400
500
600
700
0
200
400
600
800


Cholesterol Comparative VS Control tube
y = 1.0276x + 20.244
R² = 0.979
Comparative tube
Control tube
0
100
200
300
400
500
600
700
0
200
400
600
800


ALP Comparative VS Control tube
y = 1.0276x + 20.244
R² = 0.979
Comparative tube
Control tube
0
100
200
300
400
500
600
700
0
200
400
600
800


Phosphorous Comparative VS Control tube
y = 0.971x + 2.444
R² = 0.977
Comparatative tube
Control tube
0
10
20
30
40
50
60
0
20
40
60


Calcium Comparative VS control tube
y = 0.9484x + 0.3491
R² = 0.975
Comparative tube
Control tube
0
2
4
6
8
10
12
14
16
18
0
5
10
15
20


AST Comparative VS Control tube
y = 1.0254x - 0.1296
R² = 0.9929
Comparative tube
Control tube
0
2
4
6
8
10
12
14
16
0
5
10
15
20

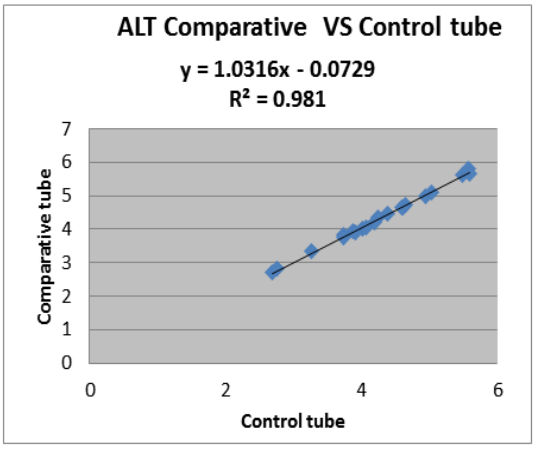

ALT Comparative VS Control tube
y = 1.0316x - 0.0729
R² = 0.981
Comparative tube
Control tube
0
1
2
3
4
5
6
7
0
2
4
6

Table 2: Clinical Verifications of Control Serum Collection Tubes.

S. No	Parameters	R^2 values	% Bias	Desirable %Bias CLSI 2025
1	Creatinine	0.979	0.00	+/- 10%
2	Urea	0.979	-0.28	+/- 9 %
3	Triglycerides	0.979	-0.87	+/- 15%
4	Glucose	0.979	-0.69	+/- 8%
5	Cholesterol	0.979	-0.36	+/- 10%
6	ALP	0.979	-0.75	+/- 20%
7	Phosphorous	0.977	-1.08	+/- 10%
8	Calcium	0.975	-0.32/0.04mg/dl	+/- 1.0 mg/dl*
9	AST	0.9929	3.24	+/- 15%
10	ALT	0.981	2.73	+/- 15%

*For calcium acceptable bias is < 1.0 mg/dl

DISCUSSION AND CONCLUSION

Serum collection tubes are often overlooked for the cause of variability in pre-analytical phase of Laboratory testing[17], This study showed the need for Technical and Clinical verification of serum collection tubes before put into use. In technical verification we observed all essential requisites for serum collection tubes are within acceptable criteria of <1%, except clotting aspect we observed inadequate clotting for control collection devices which was dialysis patient sample.

The regression analysis for clinical verification showed "R^2" values within acceptable range and % Bias well within acceptable CLSI guidelines 2025. As the validation is performed by the manufacturer it is crucial for Laboratory to verify the serum collection tubes before put into use. The Laboratory can select a suitable procedure for verification of serum collection tubes considering requirements, environmental conditions and customer outcomes. The selection and acquisition of systems for blood collection should be considered a critical aspect for assuring quality, safety, and efficiency of the pre-analytical phase of Laboratory diagnostics and therefore a total testing processes in pre analytical phases is very crucial[18] Quality specifications for validation experiments should be defined taking into consideration the Milan EFLM strategic Conference hierarchy,[19] This issue is expected to become even more important as innovative biomarker and molecular diagnostics are introduced into routine clinical practice[20,21], as this emerging arena is particularly vulnerable to pre analytical issues.[22,23]

The final evaluation should remain dependent on accuracy and precision of result reported and upon the clinical decisions the results used for differences between health and disease and also biological variation.

REFERENCE

1. Hallworth MJ. The '70% claim': what is the evidence base? Ann Clin Biochem, 2011; 48(6): 487-488.
2. Lippi G, Salvagno G, Montagnana M, Lima-Oliveria G, Guidi G, Favaloro EJ, Quality standards for sample collection in coagulation testing. Semin Thromb Hemost, 2012; 38(6): 565-575.
3. Plebani M. Errors in clinical laboratories or errors in laboratory medicine? Clin ChemLab Med., 2006; 44(6): 750-759.
4. Bowen RAR, Chan Y, Cohen J, et al. effect of blood collection tubes on total triiodothyronine and other laboratory assays. Clin Chem., 2005; 51(2): 424-433.
5. Lippi G, Banfi G, Church S, Cornes M, De Carli G, Grankvist K, et al. Preanalytical quality improvement. In pursuit of harmony, on behalf of European Federation for Clinical Chemistry and Laboratory Medicine (EFLM) Working group for Preanalytical Phase (WG-PRE). Clin Chem Lab Med., 2015; 53: 357-70.
6. Simundic AM, Lippi G. Preanalytical phase – a continuous challenge for laboratory professionals, Biochem Med (Zagreb), 2021; 22: 145-9.
7. Simundic AM, Cornes MP, Grankvist K, Lippi G, Nybo M, Ceriotti F, et al, Color coding for blood collection tube closures – a call for harmonization. Clin Chem Lab Med., 2015; 53: 371-6.
8. Magnette A, Chatelain M, Chatelain B, Ten Cate H, Mullier F, Preanalytical issues in the hemostasis laboratory; guidance for the clinical laboratories. Thromb J., 2016; 14(1): 1-14
9. Lippi G, Favaloro EJ, Preanalytical issues in hemostasis and thrombosis testing, Methods Mol Bio, 2017; 1646: 29-42.
10. Vis JY, Huisman A, Verification and quality control of routine hematology analyzers, Int J Lab Hematol, 2016; 38: 100-109.
11. Lima-Oliveria G, Lippi G, Salvangno GL, Montagnana M, Picheth G, Guidi GC. Preanalytical management; serum vacuum tube validation for routine clinical chemistry. Biochem Med (Zagreb), 2012; 22: 180-6.
12. Lima-Oliveira G,Salvagno GL, Montagnana M, Picheth G, Guidi GC. Sodium citrate vacuum tubes validation: preventing preanalytical variability in routine coagulation testing. Blood Coagula Fibrinolysis, 2013; 24: 252-5.
13. Lima-Oliveira G, Lippi G, Salvagno GL, Montagnana M, Poli G, Solero GP, et al. K(3) EDTA Vacuum Tubes Validation for Routine .Hematological Testing. ISRN Hepatol, 2012; 2012: 875357.

14. Zungun C, Yilmaz FM, Boru EG, Topcuoglu C. Comparison of Improv acuter ™tubes with BD Vacutainer™ tubes for various hormones in the aspects of stability and influence of gel separators. Clin Chem Lab Med., 2015; 53: 231-8.
15. Hantzsch M, Tolios A, Beutner F, Nagel D, Thiery J, Teupser D, et al. Comparison of whole blood RNA preservation tubes and novel generation RNA extraction kits for analysis of mRNA and MiRNA profiles. PLoS One, 2014; 9: e113298.
16. Zhang H, Korenkova V, Sjoback R ,Svec D, Bjorkman J, Kruhoffer M,et al. Biomarkers for monitoring pre-analytical quality variation of mRNA in blood samples. PLos One, 2014; 9: e111644.
17. Bowen RAR, Hortin GL Csako G, Otanez OH, Remaley AT, Impact of blood collection devices on clinical chemistry assays. Clin Biochem, 2010; 43(1-2): 4-25
18. Sandberg S , Fraser CG, Horvath AR, Jansen R, Jones G, Oosterhuis W, et al. Defining analytical performance specifications : Consensus Statement from the 1 st Strategic Conference of the European Federation of Clinical Chemistry and Laboratory Medicine.Clin Chem Lab Med, 2015; 53: 833-5.
19. Lippi et at.: EFLM WG-PRE; local validation of blood collection tubes in clinical laboratories Clin Chem Lab Med., 2016; aop.
20. Yao NA. Health Services &Policy Research in translational medicine. Ann Transl Med., 2014; 2: 72.
21. Lippi G, Plebani M .Personalized medicine: moving from simple theory to daily practice. Clin Chem Lab Med., 2015; 53: 959-60.
22. Tuck MK, Chan DW, Chia D, Godwin AK, Grizzle WE. Krueger KE et al. Standard operating procedures for serum and plasma collection: early detection research network consensus statement standard operating procedure integration working group.J Proteome Res., 2009; 8: 113-7.
23. EI Messaoudi S, Rolet F, Mouliere F, Thierry AR. Circulating cell free DNA: Preanalytical considerations. Clin Chim Acta., 2013; 424: 222-30.