Open Access Research Journal of
Science and Technology
Journals home page: https://oarjst.com/
ISSN: 2782-9960 (Online)

OARJ OPEN ACCESS RESEARCH JOURNALS

(REVIEW ARTICLE)

Preanalytical phase for transfusion medicine and blood bank laboratory – tasks to complete

Ramune Sepetiene [1, 2, *], Vaiva Patamsyte [2], Ninette F Robbins [3], Mohamed Ali [4] and Alexander Carterson [5]

[1] *Abbott GmbH Max-Planck-Ring 2, 65205, Wiesbaden, Germany.*
[2] *Lithuanian University of Health Sciences, Mickeviciaus g. 9, Kaunas, Lithuania.*
[3] *Abbott GmbH, 200 Abbott Park Road, Abbott Park, IL 60064.*
[4] *Abbott Laboratories GmbH, DAFZA, P.O. Box 32002, Dubai, UAE.*
[5] *Abbott Laboratories, 100 Abbott Park Rd, Abbott Park, IL 60064.*

Open Access Research Journal of Science and Technology, 2021, 03(01), 063–069

Publication history: Received on 07 October 2021; revised on 15 November 2021; accepted on 17 November 2021

Article DOI: https://doi.org/10.53022/oarjst.2021.3.1.0062

Abstract

Background: This review describes and evaluates the most relevant preanalytical errors and their impact on subsequent laboratory diagnostics. Quality management for laboratory processes remains extremely important, despite current advancements in information technologies and fully automated routine procedures.

Methods: This review is focused on specific preanalytical requirements for the blood bank and transfusion laboratory. Conclusions are done based on literature review.

Results: Human errors, or lack of procedures, continue to be the cause of many errors within laboratory processes. The medical laboratory needs an impetus and stipulation to improve processes, to help eliminate errors, and meet regulatory guidelines.

Conclusions: General preanalytical rules exist for clinical and research laboratories but differences in laboratory specialty and provided services influence compliance

Keywords: Transfusion Medicine; Laboratory; Preanalysis; Preanalytical errors; Quality Management.

1. Introduction

Current standards for blood sampling and standardization do not provide detailed guidelines for a specific laboratory preanalysis, such as the blood bank. However, there are general requirements for the various aspects and support functions of the lab: phlebotomy, transport, storage, or preparation of tests, etc. The guidelines provided by the ISO 15189 standard indicate the need for a preanalysis process in the context of investigation as a whole process. However, experience has shown that these guidelines are not rigorously followed [1], especially when samples are taken by untrained nurses or incompletely trained younger doctors [2]. Thereby creating opportunity for potential errors. Automation and the efforts of continuous improvement and adherence to standardization, theoretically could help reduce errors; however, preanalytical problems identified 20 years ago still remain relevant today [3].

Most publications and reports focus on how to avoid unnecessary laboratory testing, sample collection, transport and processing, and control of other discrepancies; however, mastery is needed in daily practice not just intermittently or periodically [4].

* Corresponding author: Ramune Sepetiene
Abbott GmbH Max-Planck-Ring 2, 65205, Wiesbaden, Germany.

The intent of this publication is to encourage specialists working in transfusion laboratories or blood banks to develop and adopt innovative training guidelines for their staff. Effectiveness of preanalytical knowledge and requirements will remain as constant opportunity for errors within any laboratory, hospital, or department without accountability across individuals in the entire organization.

2. Preanalytical challenges in laboratories

Lippi and colleagues stated that the overall error rate in laboratory medicine ranges from 1.1 to 3.0% [4]. The analytical errors, which most clinicians detect, account for less than 10% of all laboratory diagnostic errors, while preanalytical errors account for 46-68.2% [5], or up 70% in a more recent study [6]. Taken together, it is reasonable to conclude that the preanalytical errors account for more than 50% of all laboratory testing errors.

The preanalytical phase can be divided into two phases. The first occurs outside of laboratory, and is dependent on non-laboratory staff. The second occurs within the laboratory, and whose staff is responsible for all procedure and quality metrics [7]. As mentioned previously, there are no definite standards that separately define the

preanalytical phase, and thus can lead to gaps in the quality system. All requirements are transferred from ISO 15189 Preexamination process [8] and summarized in Table 1.

Table 1 Preanalytical factors and processing steps for laboratory testing

Factors	**Examples**	**A Guide to Fulfil requirements**
Unavoidable factors	Age, race, sex, pregnancy	Fill the request form properly
Avoidable, variable factors	Caffeine, smoking, alcohol, drugs	Ask patient and make remarks in a request form
Processing steps and requirements		
Patient preparation	Diet, starvation, exercise, altitude	Ask patient and make remarks in a request form. Responsible person
Preparation of sampling	Request form information Vacuum tubes, needles info Correct sampling procedure in place Correct sampling order	Patient and sample identification procedures – check again. Define and enter request into system. Check info for proper tube labelling and sampling order. Request form and tube are mandatory. Responsible person
Sampling process	Patient ID, timing, use of torniquet, site of sampling selection, position of needle, correct order of tubes, disinfection requirements	Patient and sample identification procedures – check again. Use of tubes, needles, disinfection materials strictly according to procedures. Responsible person
Transportation	Differences of collecting and transporting tubes, procedures in place	Collecting sites, transporting containers, cooling systems, and timing according to procedures. Responsible person
Sample treatment	Sample registration, identification, centrifugation, distribution, extraction procedures in place	Identification and registration procedures, authorized and secured laboratory information system. Responsible person
Sample/specimen storage	Selection of site, temperature, timing, utilization procedures in place	Storage and freezing devices with temperature control according to procedures. Responsible person

3. A specificity of preanalytical errors concept for transfusion service laboratory

When discussing possible preanalytical errors specifically within a transfusion service laboratory, it is important to assess all events that occur prior to testing and may impact the result. For example, the component collection bag links the blood or plasma donor and the recipient. Many opportunities for error exist during the transfer, and handling of a component bag from donor collection to eventual infusion into a recipient; with involvement by multiple personnel from different non-laboratory areas (Figure 1). The worst-case scenario could be erroneous mismatch between the donor testing samples and mislabeling info from different donor on a blood bag, and then subsequent transfusion into the wrong recipient. Wrong blood in the tube is the result of several consecutive discrepancies and the cumulative act effect. This can be partially mitigated by standardizing the process from the patient side: an identifying bracelet is placed on the patient, a test is ordered, and the phlebotomist correctly confirms the identify the patient with the identification bracelet, draws the sample, and attaches the correct label on the sample tube [9]. Mistakes can occur at each step, and analysis of transfusion practice often shows, if an error occurs in the very first stage, it tends to go through all the stages if the control procedures are inadequate and the mistake is not identified.

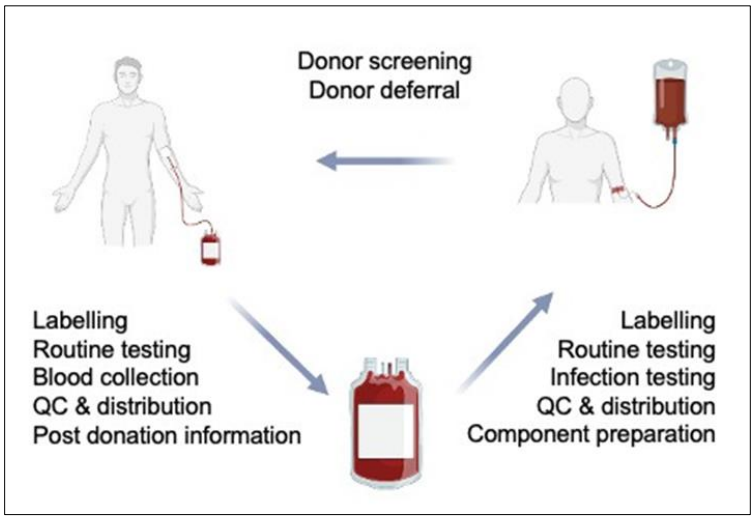

Figure 1 Transfusion preanalytical triangle

4. Patient identification errors – the fundamental error within transfusion service laboratories

The first challenge in specimen traceability is to correctly identify the patient in the Health Care facility. These challenges can present in a number of ways such as when a patient has multiple charts, or two patients receive the same chart, or a patient accepts another person's identity to seek help [9]. In one study, conducted more than 15 years ago [10] one of the 3,400 ABO blood types did not match existing or historical records. Additionally, 35 of 118 cases (30%) were attributed to registration errors mixed with forms of identity and identity theft. Recently published data from Iran study stated that technical or clerical errors accounted for 9.3% of the 130 total incidences of ABO discrepancies observed out of 322,222 blood donations [11]. In fact, most discrepant blood grouping results within analytical phase are actually due to preanalytical errors.

The ABO discrepancies are the second most common error after the sample mismatch [12] [13]. Unfortunately, it can sometimes be difficult to distinguish between the two errors. Checking the patient's ID with a photograph may reduce the potential of error but this does not eliminate these errors completely; however, future advances in biometric identification could help to eliminate these types of errors [12] [13].

The potential error of incorrect identification of a blood sample remains a constant concern for the laboratory. Most laboratories have at least three-component inspection protocols requiring at least three items to be met: 1) name, family name, 2) date of birth and 3) patient ID number. Typically, wrong blood in wrong tube errors are caught after performing ABO and D blood typing because of the practice of comparing previous patient results with the current result to ensure a match. Data from nine studies published from 1997 to 2019 in USA, show the incidence of wrong blood in tube ranged from 1: 640 and 1: 3046, with median error rate 1: 2300. It was concluded that this error occurs in blood transfusion service laboratories at a rate of 40-100 times higher than in routine clinical laboratory [9]. FDA Biological

Product Deviation Reports submitted by Transfusion Services show that the most common errors were related to transportation, incorrect testing, and patient identification (Figure 2) [14].

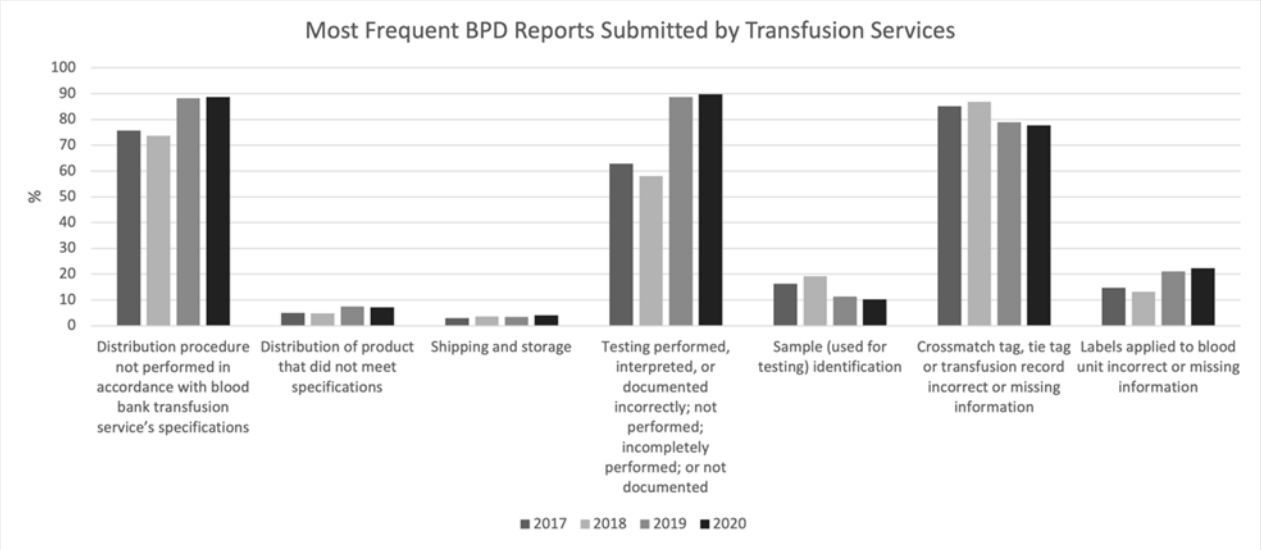

Figure 2 Most Frequent Biological Product Deviation Reports Submitted by Transfusion Services according to FDA Annual Summaries from Fiscal year 2017-2020

5. Sample selection for testing

In clinical laboratories serum and plasma are the primary sample type. Most studies are performed by comparing the results with the recommendations summarized in Table 2 [15]. Of note, when correlating repeat testing results on the same patient, the same sample type should be used. Meaning, if the primary laboratory test was done on serum, then repeat testing must be conducted using serum to ensure the comparison of results. Likewise, if plasma was used during primary testing, then repeat testing should utilize plasma. This eliminates potential confounding effects of different substrates used for same tests. However, situations do occur, such as during confirmation testing of infectious markers when the serum sample used for primary testing is discarded after 72 hours to meet storage requirements, and a plasma tube may be used for a repeat testing.

Table 2 Expected result for plasma and serum

Expected results	Plasma	Serum
Time saving (urgent tests, transportation issues, etc.)	+	-
Higher yield (large specimen required, testing panel)	+	-
Prevention of clotting effect (discrepancies occur due to clotting process)	+	-
Prevention of changes induced with coagulation process (special requirements to achieve)	+	-
Contamination with NH4-, Li+, Na+, K+ (biochemistry, immunology tests)	-	+
Inhibition of metabolic reactions from heparin (metabolic studies, enzymology)	-	+
Interference of ions distribution or binding ionized calcium and heparin (immunochemistry)	-	+
Inhibition of enzymes by metal binding to EDTA and citrate (enzymology, immunochemistry studies)	-	+

+ first choice option; - avoid to choose

If a discrepancy between results occur, auditing procedures should not permit the use of a stored plasma sample or sample taken from donor's blood or plasma bag to confirm the original result. The same sample origin and source must be used for both primary and secondary tests to confirm results regardless of whether testing reagent package inserts

state acceptable use of serum, whole blood or plasma. The recommendations on how to proceed with Transfusion Transmitted Infections (TTIs) screening are valid for use in each laboratory [16].

6. Preanalytical quality indicators

Clinical Quality Indicators (QIs) are designed to measure the achievement of goals set by the preanalysis procedure. They are worthwhile to implement to assess your current laboratory performance and to predict what measures to take to improve the overall process. A monitoring of QIs is an essential requirement for the accreditation of medical laboratories according to an international standard ISO 15189. Currently, there is not enough attention paid to the implementation of these indicators and the determination of the preanalytical value in any laboratory. Therefore, lack of monitoring preanalytical quality indicators impedes the ability of the clinical laboratories to effectively improve overall quality and error reduction costs [17]. Due to the high occurrence of errors in the preanalysis stage compared to the errors in the entire investigation process, these preanalytical errors have traditionally been treated as errors related to sample or patient identification mismatch. Based on the International Standard for Accreditation of Medical Laboratories and a patient-centered approach, there is a need for innovative and real- world QIs practices. In particular, the appropriateness of test requests and request forms needs to be urgently assessed. The QIs model developed by a working group of the International Federation of Clinical Chemistry and Laboratory Medicine (IFCC) is a valuable starting point for promoting the harmonization of available QIs, but more efforts have been made to reach a consensus on harmonization guidelines [17]. A preliminary agreement has been reached on the list of available QIs and the reporting system, which was published in 2014 [17]. Transfusion service laboratories should pay attention to preanalytical QIs proposal list (Table 3) and tailor it to their specific needs.

Table 3 Possible preanalytical errors with possible consequences/Examples of Quality Indicators

Possible error or interference	**Possible consequence or Quality Indicator to monitor**	**Corrective action**
Lack of patient identification	Wrong sample in a wrong tube	Red flag for all further processes. Refer to approved laboratory procedures
Inappropriate specimen procedures Interfering	Wrong/inadequate specimen or aliquot for testing	
biochemical substances present	Haemolysis, icterus, lipemia (HIL) may interfere test result	
Interfering sample contamination Interfering presence of drugs	Bacterial, viral contamination may interfere test result Antiretroviral, antimicrobial, antifungal therapy may directly interfere with test results	Red flag for results Refer to approval laboratory procedures
Inappropriate specimen storage selection	May interfere with final test result	

7. External Quality assessment for preanalytical phase

Several studies have described the most common errors at various stages of the laboratory diagnostics processes [18]. Models of error logging and feedback schemes have long been used by external quality assessment (EQA) organizations both in Europe and with the participation of representatives from around the world [18]. ISO 15189, the accreditation standard for medical laboratories, states that "external quality assessment programs should verify the entire test process, including pre- and post-analytical procedures" [8]. In fact, the focus is on the analytical phase and most of the proposed programs do not have a preanalysis verification module. However, there are proposed external control programs to assess the quality of the pre-analysis [19]. In principle, the quality of preanalysis can be assessed in several ways:

- Using standardized questionnaires. The advantage of this method is to identify gaps in existing procedures or the suitability of descriptions for the preanalysis process.
- Using samples for analysis with the intended preanalysis design, e.g., Interfering factors in the sample, once detected by the laboratory, suggest a further course of the process.
- Modified study for QI design. Used to combine laboratory analysis errors and link them to possible causes due to preanalysis. In this way, the laboratory gains experience in shaping QIs and evaluating them appropriately.

It should be noted that when the laboratory selects the full range of proposed external preanalytical schemes, laboratory services offer a purposeful perception of the process and form a unique quality module. All that remains is to move forward, to improve and evaluate the processes within concrete practice, by applying knowledge complexity and experience.

8. Conclusion

There are a lot of publications discussing and evaluating the Preanalytical errors with impact in total Laboratory Quality process. This review is focused on specific concerns which apply to Transfusion Service laboratories with multiple effect due to the Transfusion Preanalytical Triangle, suggested by authors of this publication. This helps to analyze the specificities of errors with modeling possibility to harmonize Quality approach choosing external preanalytical assessment schemes.

Compliance with ethical standards

Acknowledgments

Conducted literature research: R.S., V.P., N.F.R., M.A., A.C.; Analyzed the data: V.P., N.F.R., M.A., Drafted the manuscript: R.S., V.P.; Supervised and edited the manuscript: A.C.

Disclosure of conflict of interest

No conflict of interest disclosed.

References

[1] Alavi N, Khan SH, Saadia A, Naeem T. Challenges in Preanalytical Phase of Laboratory Medicine: Rate of Blood Sample Nonconformity in a Tertiary Care Hospital. Electronic journal of International Federation of Clinical Chemistry and Laboratory Medicine. 2020; 31(1): 21-27.

[2] Giavarina D, Lippi G. Blood venous sample collection: Recommendation's overview and a checklist to improve quality. Clinical Biochemistry. 2017; 50: 568-573.

[3] Almatrafi AA. Preanalytical Errors: A Major Issue in Medical Laboratory. Acta Scientific Medical Sciences. 2019; 3: 93-95.

[4] Lippi G, Plebani M, Simundic AM. Quality in laboratory diagnostics: From theory to practice. Biochemia Medica. 2010; 20: 126-130.

[5] Hammerling JA. A Review of Medical Errors in Laboratory Diagnostics and Where We Are Today. Laboratory Medicine. 2012; 43: 41-44.

[6] Najat D. Prevalence of Pre-Analytical Errors in Clinical Chemistry Diagnostic Labs in Sulaimani City of Iraqi Kurdistan. PLoS One. 2017; 12: e0170211.

[7] Sepetiene R, Sidlauskiene R, Patamsyte V. Plasma for Laboratory Diagnostics. Plasma Medicine - Concepts and Clinical Applications. 2018.

[8] ISO 15189. Medical laboratories - Requirements for quality and competence. Geneva, Switzerland: International Organization for Standardization. 2012.

[9] Ramsey, G. Landsteiner's legacy: The continuing challenge to make transfusions safe. Transfusion. 2020; 60: 2772-2779.

[10] Chiaroni J, Legrand D, Dettori I, Ferrara V. Analysis of ABO discrepancies occurring in 35 French hospitals. Transfusion. 2004; 44: 860-864.

[11] Javadzadeh S, Hayati H, Hayati A. Blood Group Discrepancies at a Regional Blood Center. International Journal of Hematology-Oncology and Stem Cell Research. 2020; 14: 38-44.

[12] Bolton-Maggs PH. SHOT conference report 2016: serious hazards of transfusion: human factors continue to cause most transfusion-related incidents. Transfusion Medicine. 2016; 26: 401-405.

[13] Ferrera-Tourenc V, Lassale B, Chiaroni J, Deltori I. Unreliable patient identification warrants ABO typing at admission to check existing records before transfusion. Transfusion Clinique et Biologique. 2015; 22: 66–70.

[14] Food and Drug Administration. Biological product deviation reports annual summaries. Silver Spring, MD: Food and Drug Administration

[15] Sepetiene R, Patamsyte V, Zukovas G, Jariene G, Stanioniene Z, Benetis R, et al. Blood Plasma TGF- β1 Concentration in Sporadic Dilatative Pathology of Ascending Aorta: More Questions than Answers. PLoS One. 2015; 10: e0129353.

[16] Screening Donated Blood for Transfusion-Transmissible Infections: Recommendations. Geneva: World Health Organization. 5, Blood screening, quarantine and release. 2009.

[17] Plebani M, Astion M, Barth J, Chen W, de Oliveira Galoro C, Escuer M, et al.Harmonization of quality indicators in laboratory medicine. A preliminary consensus. Clinical Chemistry and Laboratory Medicine. 2014; 52: 951-958.

[18] Lima-Oliveira G, Lippi G, Salvagno GL, Picheth G, Guidi GC. Laboratory Diagnostics and Quality of Blood Collection. Journal of Medical Biochemistry. 2015; 34: 288-294.

[19] Kristensen GB, Aakre KM, Kristoffersen AH, Sandberg S. How to conduct External Quality Assessment Schemes for the pre-analytical phase? Biochemia Medica (Zagreb). 2014; 15: 114-22.