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Verification of analytical performance of Unsaturated iron binding capacity (UIBC) assay on the Abbott Alinity ci®: Experience of the central laboratory of Mohammed VI University Hospital of Oujda

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Abstract

The verification of analytical methods is a requirement outlined by the International Organization for Standardization (ISO). This process involves evaluating the performance of an analytical method according to a well-defined protocol and subsequently comparing it with pre-established analytical objectives. In our study, we conducted an evaluation of the analytical performance of the unsaturated iron binding capacity assay using the Abbott kit on the Alinity CI analyzer in the biochemistry laboratory of Mohammed VI University Hospital in Oujda. The methodology employed adheres to the recommendations of the French accreditation committee (COFRAC) accreditation technical guide SH GTA 04, focusing on the assessment of reproducibility and repeatability. Overall, the results obtained from the study are considered satisfactory and align with the acceptability criteria recommended by the supplier. It's important to note that the accuracy and reliability of examination results are influenced not only by laboratory personnel, equipment, and environmental conditions, but also by the methods utilized and their eventual validation or verification.

Keywords: UIBC assay; Analytical performance; Repeatability; Reproducibility; Alinity CI analyzer

1. Introduction

Quality is an ongoing process aimed at ensuring the accurate performance of tests consistently and without fail. A quality assurance system encompasses all internal and external laboratory activities, along with proper laboratory practices and improved management skills. Its purpose is to guarantee that each assay is conducted by the laboratory is accurate and reliable. Implementing quality concepts in medical laboratories necessitates the establishment of a targeted quality management process to uphold the reliability of the results(1).

Verification of method play a crucial role in that process, it consists on assessing the analytical performance of an assay method used by the laboratory, to ensure its reliability, consistency and precision. this process includes following a standardized operating protocol, then judging them against criteria defined by learned societies (RICOS, FSCB) or the supplier. Moreover, the verification of an analytical performance is both a regulatory requirement outlined in The Moroccan Guide for the good performance of Medical Laboratory Analysis (GBEA) and a normative standard according to ISO 15189:2022(2,3).

Unsaturated Iron Binding Capacity (UIBC), a metric that reflects the iron-binding capacity of apo transferrin in the blood serum. The assessment of unsaturated iron binding capacity is crucial for assessing iron status disorders, providing valuable diagnostic insight into iron deficiency(4). Unlike traditional iron markers like serum ferritin and hemoglobin,

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UIBC offers unique perspectives, reflecting the body's iron-binding capacity. Increased UIBC signifies elevated unoccupied transferrin binding sites in iron deficiency, aiding clinicians in timely intervention and accurate patient management(5). Additionally, UIBC helps differentiate iron deficiency from anemia of chronic inflammation (ACI), where traditional markers fail(6).

Our study delves into the comprehensive evaluation of the analytical performance of the UIBC assay when implemented on the Abbott Alinity ci Automated System. The study aims to rigorously assess various critical parameters, including precision, accuracy, and reliability. By elucidating the system's ability to provide reliable UIBC measurements, this evaluation contributes not only to the advancement of clinical laboratory practice but also to the overall understanding of iron-related disorders and their diagnostic methodologies.

1.1. Principle of the assay method

In the present procedure, a representative sample is introduced into an alkaline buffer, wherein a pre-determined concentration of iron is present. The rationale behind this step is to achieve saturation of available binding sites on the transferrin molecules. After the saturation process, any remaining unbound iron is subjected to reduction, resulting in the conversion of the iron to its ferrous state. This reduced iron is then engaged in complexation with Ferene-S*, forming a chemically stable complex. The intensity of color exhibited by this complex is subsequently quantified at a wavelength of 604 nm.

The observed color intensity stands in direct correlation with the concentration of unbound excess iron and conversely relates to the unsaturated iron-binding capacity. In effect, the determination of Unsaturated Iron Binding Capacity (UIBC) entails a dual evaluation. First, it involves the deduction of unbound iron quantity from the total initially introduced iron quantity, thereby providing a measure of the excess iron that remained unbound. Subsequently, this value is utilized to infer the capacity of transferrin to bind iron in an unsaturated state. This procedural strategy yields a quantification of UIBC, furnishing valuable insights into the iron-binding dynamics of the analyzed sample.

2. Materials and methods

This study is a prospective investigation conducted within the biochemistry laboratory of Mohammed VI University Hospital. Our aim was to assess the analytical performance of UIBC determination, using the "Chemistry" module on the Abbott Alinity ci® Analyzer. The study was carried out within a specified period, and the working methodology adhered to the recommendations of the French accreditation committee (COFRAC) accreditation technical guide GTA 04 protocol. The findings from this study will provide valuable insights into the accuracy and reliability of UIBC determination using the Alinity ci® analyzer in a hospital setting. The study was designed in two distinct phases. Initially, we proceeded with an evaluation of intermediate fidelity test, also known as intra-laboratory reproducibility test by conducting daily internal quality controls with varying concentrations—low, medium, and high—over a period of 30 days. In the second phase, three samples were chosen randomly from the daily patient samples to represent the full spectrum of Unsaturated Iron Binding Capacity (UIBC) levels. Each of these samples was then classified into three groups representing low, medium and high levels of UIBC. To assess repeatability, each serum sample underwent 30 individual assays.

The assessment of Unsaturated Iron-Binding Capacity (UIBC) utilized a dedicated reagent kit on the chemistry module. Following this, data processing occurred through the intermediary BYG middleware, connecting the Alinity platform to the iLab result validation software. The coefficient of variation (CV) values obtained in this investigation were then compared to the benchmarks outlined by respected professional organizations and the supplier, specifically the Federation of Clinical Chemistry and Laboratory Medicine (FSCB) and the Reference Institute for Bioanalytics (RICOS).

3. Results

3.1. Intermediate fidelity results

The results of the intermediate fidelity examination demonstrate satisfactory outcomes across low, medium, and high levels, with coefficients of variation CV1, CV2, and CV3 of 2.13%, 2.23%, and 2.67%, respectively.

These findings have been visually represented through Levey-Jennings plots (Fig. 1, Fig. 2, and Fig. 3) to provide additional clarity on the observed results.

Table 1 Intermediate fidelity results of UIBC blood assay by level with comparison to supplier

Level of Internal quality control (IQC)	Results of intermediate fidelity			Results of Supplier		
	Mean (ug/dl)	Standard deviation	CV%	Mean (ug/dl)	Standard deviation	CV%
Low level	99.9	2.12	2.13%	150	4.9	3.3%
Medium level	133.33	2.96	2.23%	208	5.9	2.8%
High level	153.50	4.09	2.67%	267	5.0	1.9%

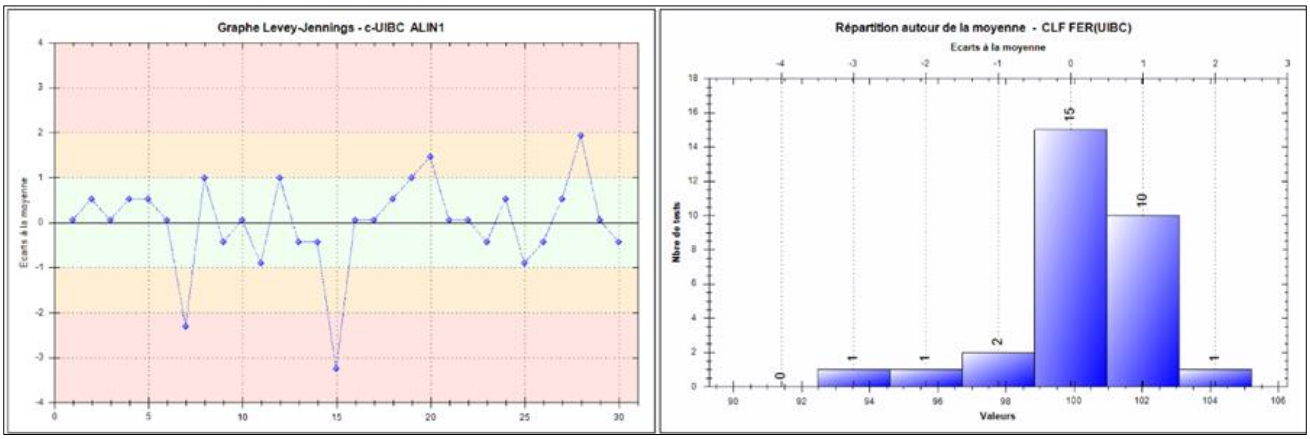

Figure 1 Low level of intermediate fidelity: Levey Jennings graph and the distribution around the mean

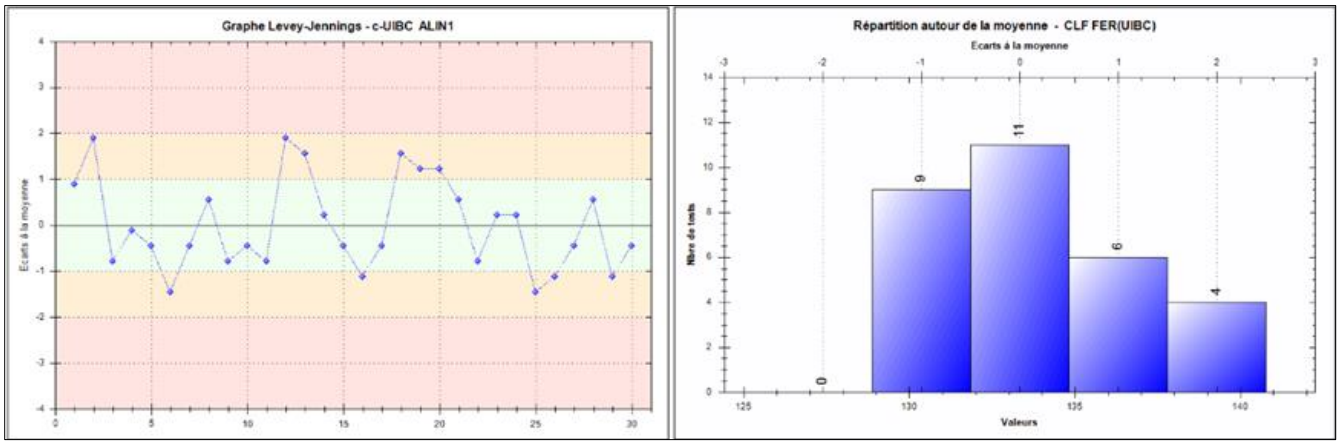

Figure 2 Medium level of intermediate fidelity: Levey Jennings graph and the distribution around the mean

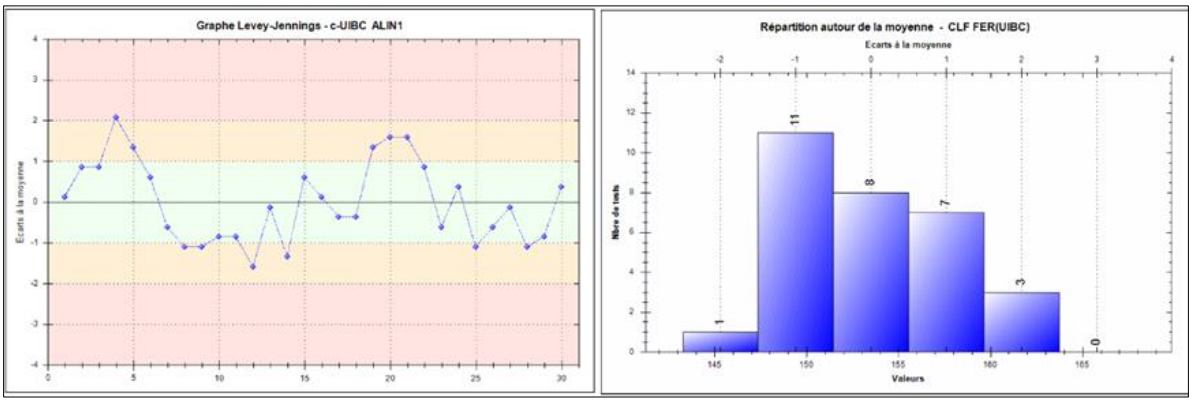

Figure 3 High level of intermediate fidelity: Levey Jennings graph and the distribution around the mean

3.2. Repeatability results

The results obtained from the evaluation of repeatability test exhibited commendable levels of repeatability for both low, medium, and high concentration ranges, as indicated by CV1 of 1.33% and CV2 of 0.73% and CV3 of 0.85% respectively.

These findings are visually presented through Levey Jennings plots, illustrating the results in a more comprehensive manner (Fig. 4, Fig. 5 and Fig. 6).

Table 2 Repeatability results of UIBC blood assay by level with comparison to supplier

Level of Internal quality control (IQC)	Results of repeatability			Results of supplier		
	Mean (ug/dl)	Standard deviation	CV%	Mean (ug/dl)	Standard deviation	CV%
Low level	99.97	1.32	1.33%	150	2.4	1.6%
Medium level	144.0	1.65	0.73%	208	2.9	1.4%
High level	170.6	1.45	0.85%	267	2.8	1.1%

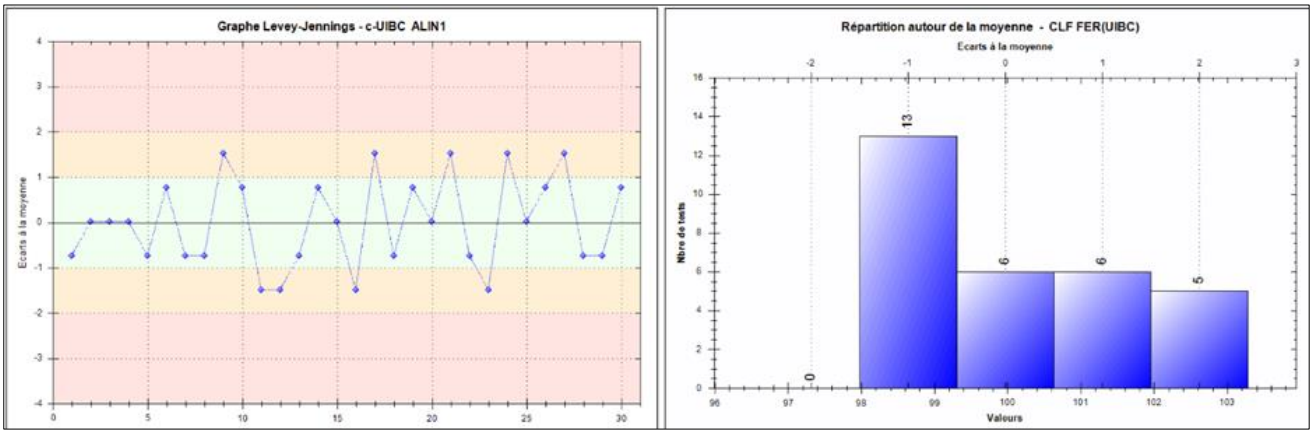

Figure 4 Low level of repeatability: Levey Jennings graph and the distribution around the mean

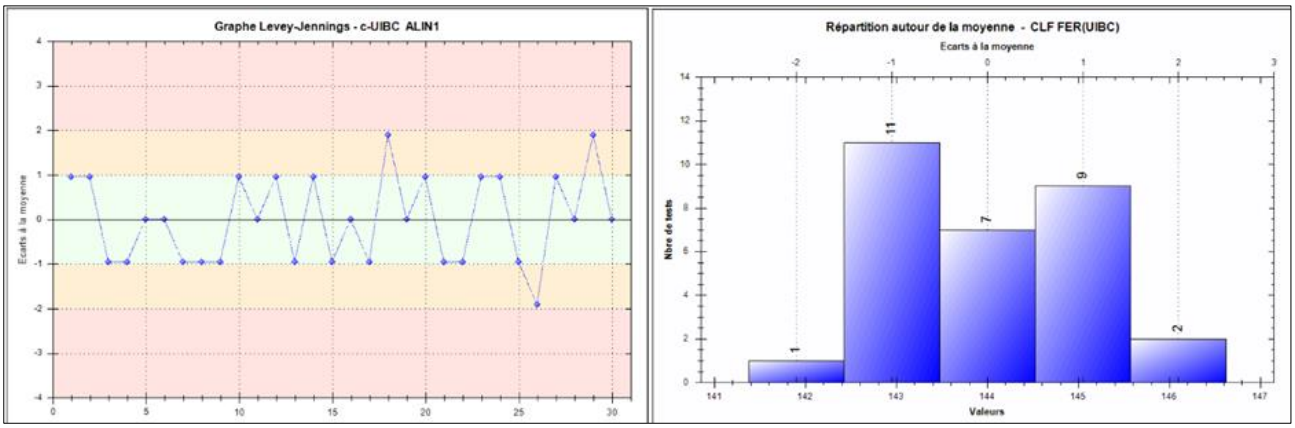

Figure 5 Medium level of repeatability: Levey Jennings graph and the distribution around the mean

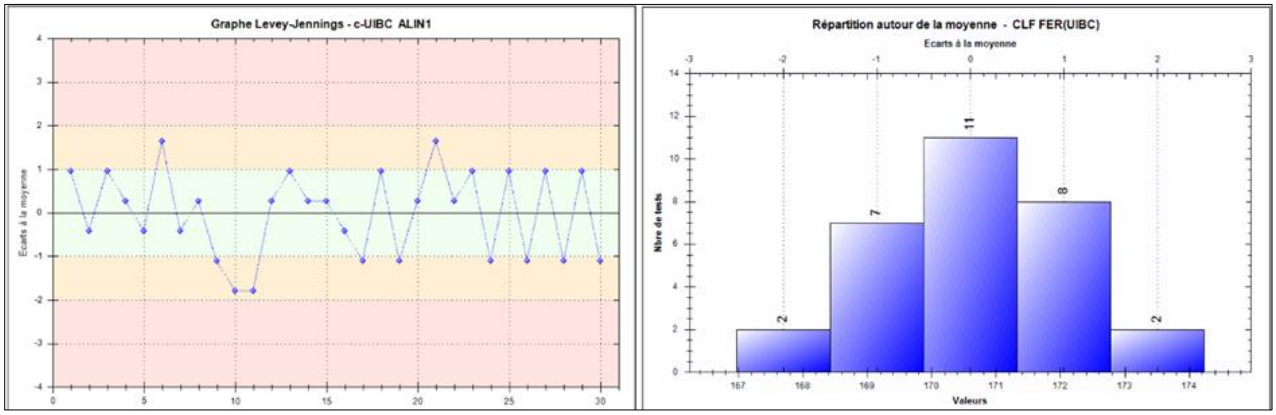

Figure 6 High level of repeatability Levey Jennings graph and the distribution around the mean

4. Discussion

Among the array of iron-related biomarkers, the determination of Unsaturated Iron Binding Capacity (UIBC) emerges as a critical parameter for assessing iron status disorders. The UIBC determination can provide important diagnostic insight into iron deficiency as it remains one of the most prevalent nutritional disorders worldwide, affecting diverse populations across age groups(4). Traditional indicators of iron deficiency, such as serum ferritin and hemoglobin levels, have limitations in specific clinical scenarios, including inflammation and certain chronic diseases(7). UIBC, as a measure of the available capacity of transferrin to bind iron, offers a unique perspective. In iron deficiency, increased UIBC signifies elevated unoccupied transferrin binding sites, indicating the body's attempt to augment iron uptake. By integrating UIBC determination into diagnostic algorithms, clinicians gain a more nuanced understanding of iron deficiency states, ensuring timely intervention and accurate patient management(8). Also, the determination of UIBC can assist in differentiating iron deficiency from anemia of chronic inflammation (ACI), distinguishing iron-deficient anemia from anemia of chronic inflammation presents a diagnostic challenge due to similar alterations in traditional iron markers. ACI is characterized by limited iron availability despite sufficient iron stores. UIBC aids in this differentiation by its response to inflammation. While UIBC increases in iron deficiency, ACI often presents with a blunted UIBC response due to impaired iron release from reticuloendothelial stores. Incorporating UIBC assessment contributes to more precise classification, enabling targeted therapeutic strategies(6,7).

UIBC determination is also pertinent for monitoring Hemochromatosis and Iron Overload Disorders, such as hereditary hemochromatosis., demand accurate methods to assess excess iron burden. UIBC assumes significance here by indicating the capacity of transferrin to bind iron when saturation approaches maximum levels. Reduced UIBC, coupled with elevated serum ferritin and transferrin saturation, suggests the potential for iron overload(9). Integrating UIBC assessment aids in early detection, enabling proactive management to prevent severe organ damage. The UIBC assay also holds promise beyond traditional iron-related disorders. Inflammatory conditions and malignancies often perturb

iron metabolism, impacting patient outcomes. Monitoring UIBC in these contexts facilitates understanding the interplay between inflammation, iron utilization, and disease progression. Dynamic changes in UIBC may serve as prognostic indicators and aid treatment monitoring(4).

In this study, we have performed a verification of analytical performance of unsaturated iron binding capacity assay using the chemistry module on the Abbott Alinity ci analyzer, this procedure falls under 'the flexible category A' for method verification, a process that can be conducted following the recommendations of COFRAC guide SH-GTA-04(10). A full method validation was not required; rather, method verification aligning with laboratory practices suffices. Sensitivity and specificity of the techniques need not be verified. On the other hand, the central laboratory of Mohamed VI University Hospital of Oujda committed to maintain the highest standards of analytical performance and to deliver reliable and accurate laboratory results for patients.

The verification process involved evaluating the repeatability and intermediate fidelity tests. Those two statistical assessments enabled us to determine the closeness of agreement between the UIBC measurands results or test value obtained through multiple estimation in replicates under specific conditions(1,11).

The intermediate fidelity test permitted us to evaluate the consistency of assay results in the presence of diverse variables. These variables include fluctuations in operators, time intervals, reagent kits, and calibrations—all of which can influence result reliability. To quantify this variability coefficients of variation (CV) were used(12,13). The Coefficients of variations obtained from the study intermediate fidelity have demonstrated the reliability of UIBC assay. The three levels were overall satisfactory (table 1), with CV1, CV2 of 2.13%, 2.23%, and 2.67% respectively. The findings indicate that the UIBC assay using colorimetric method is robust and stable under diverse conditions. The minimal coefficient of variation (CV) values suggest that even when variables like operator or reagent batch change, the assay consistently yields results closely aligned with the mean value. This reliability holds significant importance in medical diagnostics, where consistent and trustworthy test results are essential for clinical decision-making. Moreover, the alignment of CV values with established quality control limits affirms that the assay meets supplier standards for reproducibility, thereby reinforcing its suitability for accurate diagnostic applications.

As for, the repeatability study, it allows us to evaluate the precision of the assay results by assessing the same sample under the same conditions, using same operator, same reagent kits, same calibration, and within the shortest timeframe possible(10,14). The results obtained were very satisfactory, and the coefficients of variations were remarkably low (table 2). These results have demonstrated high precision of the UIBC assay. Such precision holds a paramount importance when it comes to decision-making, especially where even minor variations can significantly impact clinical decision.

Upon examination of repeatability and intermediate fidelity for the unsaturated iron binding capacity assay using colorimetric method, it was determined that these parameters were satisfactory overall and meet supplier requirements. In summary, the verification of the analytical performance of UIBC determination, used on chemistry module of the Abbott Alinity analyzer suggests its suitability for use in medical laboratories. Moreover, the compilation of a technical verification/validation dossier is a crucial component for any medical analysis laboratory aspiring to achieve accreditation in accordance with ISO 15189 standards.

5. Conclusion

In summary, the verification of analytical performance of UIBC assay on the Abbott Alinity CI analyzer using colorimetric method unveiled robust, reliable, and precise. The results obtained from the evaluation of repeatability and intermediate fidelity were overall satisfactory and have meet the quality requirements of supplier. These qualities are paramount in clinical diagnostics, where accurate and dependable results are crucial for patient care.

Compliance with ethical standards

Acknowledgment

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Disclosure of conflict of interest

The authors declares that they have no known competing financials interests or personal relationships that could have appeared to influence the work reported in this paper.

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