Internal quality control of glucose during the period of the on- call duty in a biochemistry laboratory in Antananarivo

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ABSTRACT

Reliability is one of the priorities in medical analysis laboratories. Regular internal quality control allows us to validate and guarantee the good quality of the results of each test performed. The objective of this study was to evaluate the quality of the glucose analysis carried out in the biochemistry laboratory of the University Hospital Center of Joseph Ravoahangy Andrianavalona during the period of the on-call duty in a biochemistry laboratory in Antananarivo. It is a descriptive retrospective study carried out over a period of three months. The coefficient of variation was calculated using the quality control values of automaton BS 300 Mindray. Westgard rules were applied to analyze the Levey-Jennings graphs. To be precise the dosage must have a Coefficient of variation < 5,0 %. Coefficients of variation > 5.0 % were found in 50% of cases. To be accurate, a method must have a criterion 10% < 10. The assessment of the accuracy of the measuring tool showed that the amount of glycemia was generally within acceptable ranges. The Westgard rules were not always followed. Westgard's rule 10X was violated. Rule 1_{3S} was not followed in April and May. Rule 2_{2S} was violated in June. The training of interns in medical biology, the regular monitoring of internal quality controls and the search for the causes of errors could improve the quality of the results.
This preliminary study provides information on the quality of our analytical process during the period of the on-call duty.

Key words: Biochemistry, Internal Quality Control, glucose, Westgard rule.

RESUME

Le souci de fiabilité est l'une des priorités dans les laboratoires d'analyse médicale. Le contrôle de qualité interne régulier permet de valider et de garantir la bonne qualité des résultats de chaque test effectué. L'objectif de cette étude était d'évaluer la qualité de l'analyse de glucose effectuée dans le laboratoire de Biochimie du Centre Hospitalier Universitaire Joseph

Ravoahangy Andrianavalona en période de garde. Il s'agit d'une étude rétrospective descriptive réalisée sur une période de trois mois. Les valeurs de contrôle de qualité de l'automate BS 300 de Mindray ont permis de calculer le coefficient de variation. Nous avons appliqué les règles de Westgard pour analyser les graphiques de Levey-Jennings.

Des coefficients de variation CV > 5,00 % ont été constatés dans 50 % des cas. L'appréciation de l'exactitude de l'instrument de mesure a montré que le dosage de la glycémie a été dans l'ensemble inclus dans des fourchettes acceptables. Les règles de Westgard n'ont pas été toujours respectées. La règle 10X de Westgard a été violée. La règle 1_{3S} n'a pas été respectée en mois d'Avril et Mai. En mois de Juin, la règle 2_{2S} a été violée. La formation des internes, le suivi régulier des contrôles de qualité interne, la recherche des causes des erreurs pourraient améliorer la qualité des résultats.
Cette étude préliminaire permet d'obtenir des informations sur la qualité de notre processus analytique durant la période de garde.

Mot s clés : Biochimie, Contrôle qualité interne, glucose, règle de Westgard.

INTRODUCTION

The result of a biochemical examination plays a very important role in patient management. The results must be reliable and delivered as quickly as possible [1]. In this respect, the biologist's constant concern is to guarantee the reliability of the results in accordance with his or her obligations towards colleagues and patients. Internal quality control is a methodological tool for the regular monitoring of analytical performance. It is a set of scientific processes used to evaluate the analytical process that produces a result [2]. Few medical analytical laboratories in developing countries, especially in sub-Saharan Africa, have been accredited despite the establishment of international plans for quality assessment in the medical laboratory by the World Health Organization (WHO) [3-4]. For Madagascar, few studies have been carried out on internal quality control of biochemical parameters. This study aimed at evaluating the quality of glucose analysis performed in the biochemistry laboratory of the University Hospital Center of Joseph Ravoahangy Andrianavalona during on-call period.

MATERIALS AND METHODS

This is a descriptive retrospective study carried out within the Paraclinical Training and Research Unit (UPFR) Biochemistry of the University Hospital Center of Joseph Ravoahangy Andrianavalona in Antananarivo over a period of three months from April 1st to June 30th 2016 and during the on-call period. The on-call period includes the interval between 5 p.m. and 7 a.m. the next day for working days and during the 24 hours of public holidays and weekends. The test parameter for this control was blood glucose. It is a biochemical parameter frequently requested in emergency situations but a very useful parameter in certain serious pathological situations.

To carry out this work, we have used :

- Two batches of lyophilised commercial control sera: a normal internal quality control serum (Control 1) MULTISERA N LINEAR Batch No. 15178 and a pathological control serum (Control 2) MULTISERA P LINEAR Batch No. 19704, supplied by LINEAR CHEMICALS SL laboratory based in Barcelona, Spain. Reconstitution of the

control specimens was done according to the recommendations of the supplier; that is to say, solution of the lyophilisate and homogenisation after 30 minutes.
- Glucose reagent kits
- Mindray BS-300® multiparameter automaton.

The department's multi-parameter automated biochemical analyzer: Mindray BS-300®operates 24 hours a day, so the unit has defined two levels of controls to validate the daily analytical process. The glucose oxidase method at end point was used. The first Internal Quality Control was performed at 07:00 in the morning, the second one was performed from 17:00 to validate the evening series of analyses. Only the results of the second internal quality control were recorded and used to assess the quality of the analytical process in this study.

The average values of both normal and pathological control samples are plotted on a Levey-Jennings graph [5] using the average (X) and standard deviation calculated from the average values obtained.

The day-by-day Internal Control Quality results of glucose allowed us to calculate the coefficient of variation (CV) to assess the precision and accuracy of our analytical process. These results were then analyzed according to Westgard rules [6] to determine the minimum acceptable or unacceptable risk for a series of analyses when using two control sera.

Westgard rules state that :

- The series of dosage is accepted if the results of both batches are each within $X \pm 2_S$
- The series is rejected (or put under monitoring measures) in one of the following cases:
  - A value of a control sample is outside the interval $X \pm 3_S$ (lack of accuracy or repeatability): rule 1_{3S}.
  - Two consecutive values are outside the interval X ± 2S, and on the same side of the average (inaccuracy): Rule 2_{2S}.
  - The difference between the results of the two batches reaches or exceeds 4S (lack of repeatability): Rule 4_S
  - Four consecutive values are on the same side of the X value ±: rule 4_{1S}.
  - Ten consecutive values are on the same side of the average: rule 10X.

Acceptability limits are limits of imprecision, accuracy error and total error. The acceptability limits selected for the parameter is represented by the respective values of the calculated coefficients of variation.
Precision allows an assessment of the dispersion around the average, the results obtained after fractionated dosing of a sample, thus highlighting fortuitous or random errors. Precision is assessed by the coefficient of variation (CV).

$$CV = \frac{SD}{X} X100$$

SD : Standard deviation X : average

It is expressed as a percentage (%). The larger the CV, the less precision the dosage is. To be precise the dosage must have a CV < 5% [7-10]. The exploitation of the results used the XPS software, for the calculation of averages, standard deviations.

Accuracy is defined as the agreement between the observed outcome and the true or most probable result. In fact, it is calculated by the difference between the theoretical or true value (C) and the value produced (V) by the technician.
The greater this difference, the more inaccurate the measurement. Lack of accuracy results in a systematic error that is found in every dosage.
Accuracy can be determined by statistical calculation [9, 10].

$$\frac{C - V}{C} X\ 100$$

To be accurate, a method must have a criterion 10% < 10.

RESULTS

Values of controls, average X, SD and CV

The values of normal controls C1 and pathological controls C2, average X, standard deviations SD and coefficients of variation CV for the months of April, May and June are shown in Table I, II, III, IV, V and VI.

Table I. Values of normal controls C1 from April 1 to April 30, 2016

D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D11	D12	D13	D14	D15
6.05	6.09	6.10	5.91	5.89	5.88	5.83	5.81	5.85	5.95	5.57	5.62	5.89	6.11	5.97

D16	D17	D18	D19	D20	D21	D22	D23	D24	D25	D26	D27	D28	D29	D30
6.04	6.10	5.97	5.86	5.95	2.21	5.81	5.86	5.86	5.84	5.63	5.56	6.06	5.99	6.00

Average X of normal control C1: 5,77 SD:0,69 CV (%):11,9

Table II. Values of pathological controls C2 from April 1 to April 30, 2016

D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D11	D12	D13	D14	D15
15.13	15.34	15.19	14.65	14.86	14.61	14.24	13.95	14.04	14.88	13.95	14.00	14.72	15.24	15.17

D16	D17	D18	D19	D20	D21	D22	D23	D24	D25	D26	D27	D28	D29	D30
15.10	15.22	14.94	14.75	14.92	14.65	14.13	14.11	14.48	14.80	14.13	13.95	15.17	15.18	14.93

Average X of pathological control C2 :14,68 SD:0,46 CV(%) :3,2

Table III. Values of normal controls C1 from May 1 to May 31, 2016

J1	J2	J3	J4	J5	J6	J7	J8	J9	J10	J11	J12	J13	J14	J15
5,98	6,01	5,95	6,04	5.90	6,71	6,17	6,71	6,58	6,63	6,99	7,00	6,91	6,70	6,82

J16	J17	J18	J19	J20	J21	J22	J23	J24	J25	J26	J27	J28	J29	J30	J31
6,76	5,99	5,81	5,92	6,04	6,79	11,67	6,64	6,75	6,61	6,71	8,46	6,88	6,86	6.71	6,62

Average X of normal Control C1 :6,72 SD:1,05 CV(%):15,7

Table IV. Values of pathological controls C2 from May 1 to May 31, 2016

J1	J2	J3	J4	J5	J6	J7	J8	J9	J10	J11	J12	J13	J14	J15
15,05	15,36	15,39	15,44	16,02	16,66	16,51	16,59	16,45	16,52	17,28	17,46	17,26	16,98	17,08

J16	J17	J18	J19	J20	J21	J22	J23	J24	J25	J26	J27	J28	J29	J30	J31
16,93	15,12	15,29	15,46	15,48	16,97	11,69	16,54	16,40	16,61	16,97	11,05	17,25	17,07	16,85	16,89

Average X of pathological Control C2 :16,08 SD:1,45 CV(%):9,04

Table V. Values of normal controls C1 from June 1 to June 31, 2016

J1	J2	J3	J4	J5	J6	J7	J8	J9	J10	J11	J12	J13	J14	J15
6,84	6,83	6,77	6,75	6,70	6,85	6,79	6,77	6,60	6 ,64	6,69	6,61	6,78	6,65	6,58

J16	J17	J18	J19	J20	J21	J22	J23	J24	J25	J26	J27	J28	J29	J30
6,83	6,92	6,79	6.75	6,85	6,81	6,81	6,70	6,70	6,68	6,62	6,61	6,78	6,73	6,66

Average X of normal Control C1 :6,73 SD:0,08 CV(%):1,3

Table VI. Values of pathological controls C2 from June 1 to June 31, 2016

J1	J2	J3	J4	J5	J6	J7	J8	J9	J10	J11	J12	J13	J14	J15
17,13	16,99	16,92	16,60	16,85	16,66	16,51	16,69	16,87	16,82	16,88	16 ,60	17,00	16,80	16,50

J16	J17	J18	J19	J20	J21	J22	J23	J24	J25	J26	J27	J28	J29	J30
17,04	17,19	17,01	16,81	17,10	16,55	16,39	16,48	16,79	16,77	16,82	16,82	17,02	17,04	16,96

Average X of pathological Control 2 :16,820 SD:0,212 CV(%):1,2

Coefficients of variation CV > 5.0 % were found in 50 % of cases (Table VII). The assessment of the accuracy of the measuring tool showed that the dosage of the blood sugar was generally within acceptable ranges (Table VIII).

Table VII. Results of Coefficients of variation CV (%)

	April		**May**		**June**	
	C1 (N)	**C2 (P)**	**C1 (N)**	**C2 (P)**	**C1 (N)**	**C2 (P)**
Glucose	**11,9**	3,2	**15,7**	**9,04**	1,3	1,2

*C1 (N): Normal control C2 (P): Pathological control

Table VIII. Results of accuracy

	April		**May**		**June**	
	C1 (N)	**C2 (P)**	**C1 (N)**	**C2 (P)**	**C1 (N)**	**C2 (P)**
Glucose	-8,12	-4,64	7,00	4,41	7,16	9,22

Validation of daily series according to Westgard rules

For the controls of April, the pathology control C2 value on Day 12 exceeds the -3SD limit (figure 1). The results of normal control C1 and pathological control C2 are on the same side of the average X, below the average (figure 1).

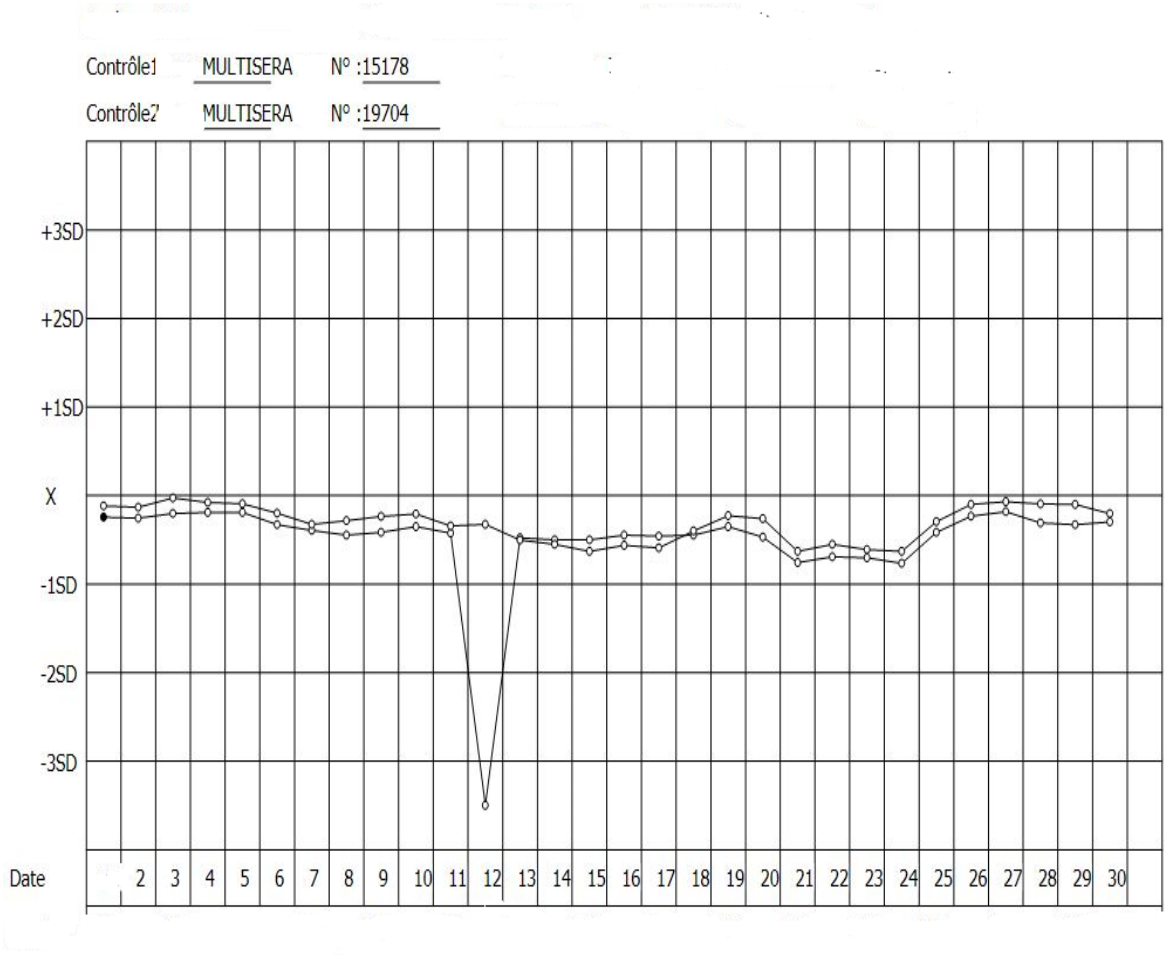
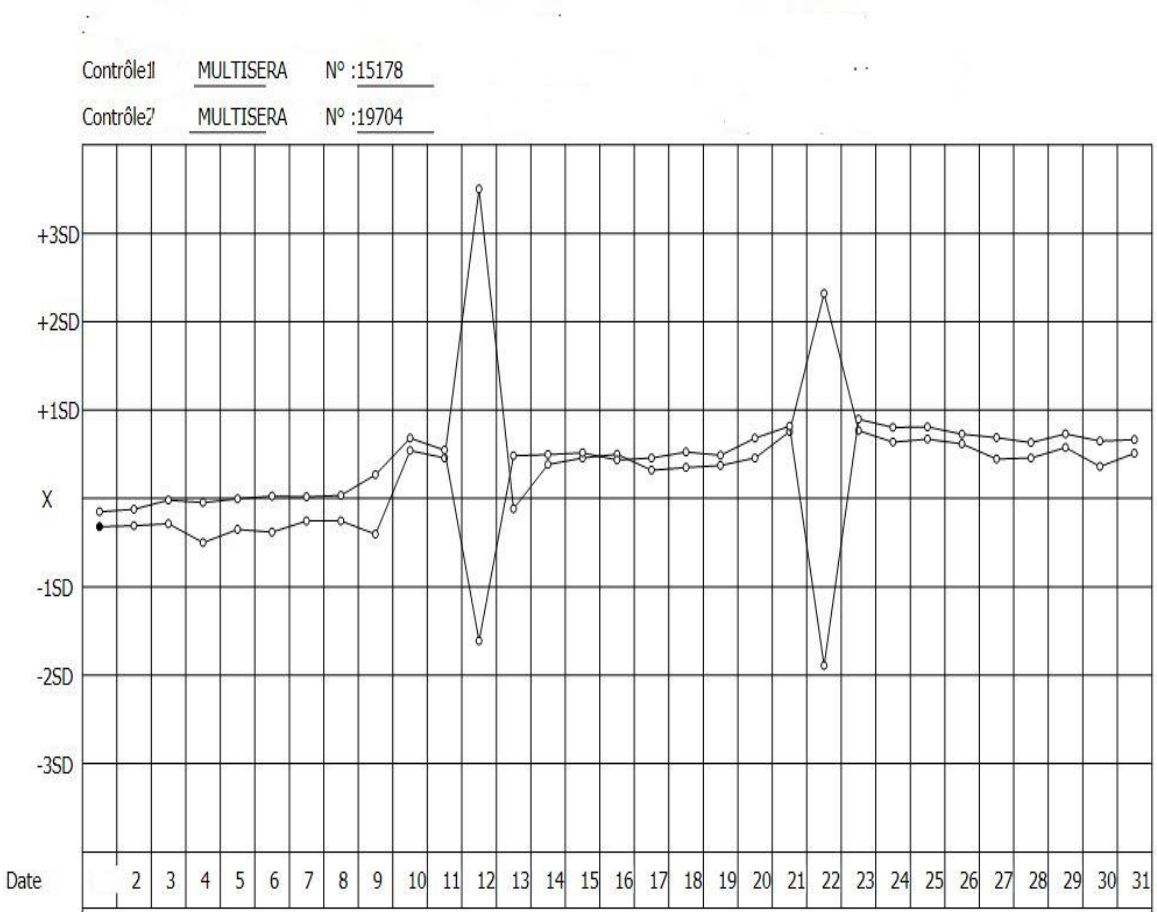


Figure 1. Levey-Jennings Chart for the level I and level 2 controls from 1 to April 30, 2016

For the controls of May, from Day 14 onwards, the results of the normal and pathological control are on the same side of the average X, above the average, except for the value of the pathological control on Day 22 which is within the -2SD limit. On the other hand, the pathological control value on Day 12 exceeds the +3SD limit (Figure 2).



*C1 : curve above C2 : curve below

Figure 2. Levey-Jennings Chart for the level 1 and level 2 controls from 1 to May 31, 2016

For the controls of June, the results of the two batches are each in the limits of X ± 2S. Only, all these results are on the same side of the average X, above the average (Figure 3).

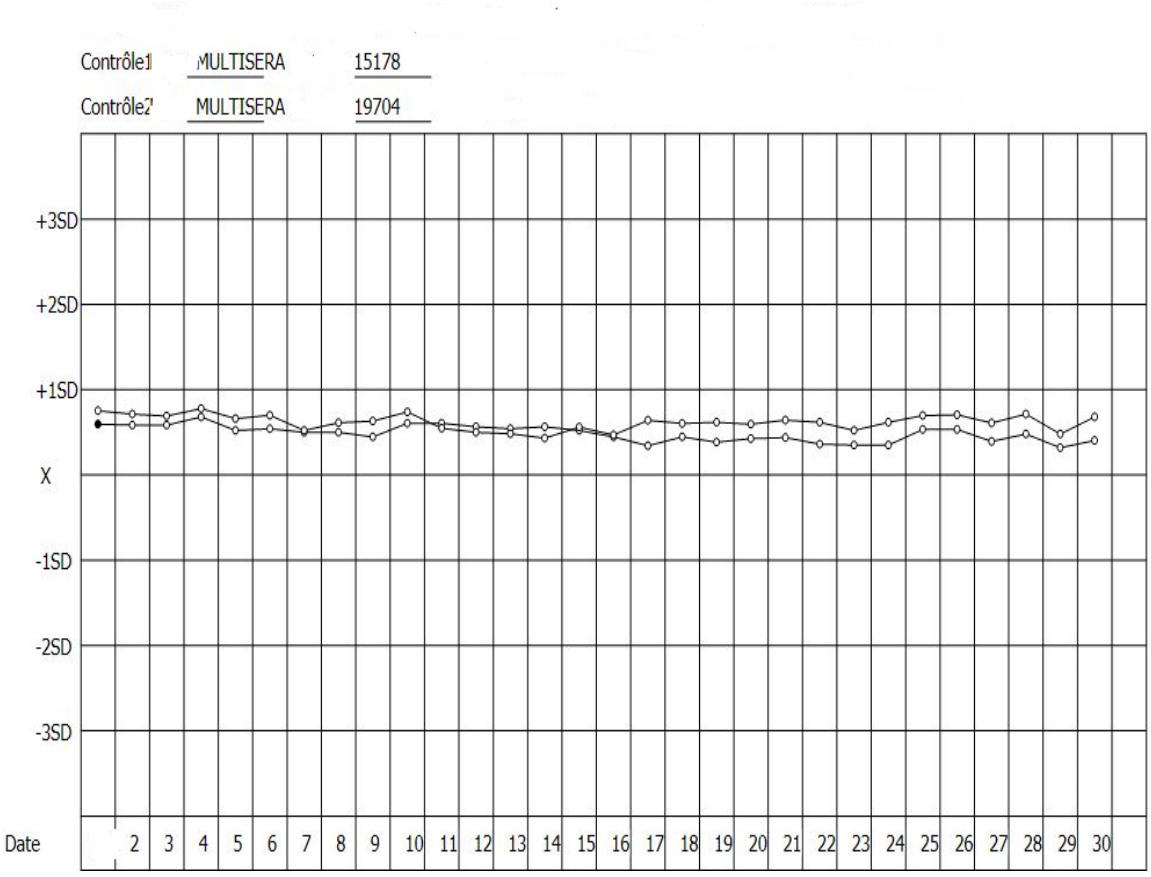


Figure 3. Levey-Jennings Chart for the level 1 and level 2 controls from 1 to June 30, 2016

DISCUSSION

Level of precision and accuracy

According to some authors and the French Society of Clinical Biology, to be precise the dosage should have a CV < 5,0 % [7-10]. Coefficients of variation CV > 5% were found in 50% of our results. This imprecision affects reproducibility and indicates a random error. It can be a random error due to incorrect pipetting, insufficient sample and reagent, failure to incubate the sample (time, temperature) and incorrect calibration. According to S. DRZEVIECK the imprecision of measurements could be related to reagents, equipment, personnel, calibration and internal control procedures [12].

According to the literature, a method must have a criterion of 10% < 10 to be accurate. The assessment of the accuracy of the measuring tool showed that the amount of glycemia was generally within acceptable ranges

Validation of daily series according to Westgard rules

The graph of the Internal Quality Control of glucose shows a violation of Westgard's rule 10X affecting the 3 months of the study. Thus, there is a systematic error with the normal and pathological control serum values. The errors detected are progressive losses of reliability in our analytical system. As in the literature, they may be due to problems with reagent storage, gradual temperature variation in the laboratory, lack of maintenance of our analytical equipment and calibration errors [3,13-14]. But they can also be related to the average that has to be recalculated.

Technically, random errors are errors in excess that occur accidentally. In this study, random errors are mainly highlighted by the violation of Rule 1_{3S} and Rule R4s. We can suspect that random errors in this study may be related to the technician such as non-compliance with the protocol, incorrect use of equipment. These errors can be avoided by careful reading of the protocol, the schematization of the operating steps, the organization in time by identifying the critical points of handling and by respecting the "guides for proper conduct of analyses" (GBEA) in the laboratories [15]. Technical problems are those that affect standard operating procedures or analytical methods that are not followed, such as dilution errors, pipetting errors and reagent contamination. Other studies have also shown that the training of laboratory staff improves the quality of test results [16]. For example, SAWADOGO M has found that periodic changes in laboratory handling teams can induce variations in the quality of services [3]. In our case, the on-call period is provided by interns in medical biology. They have very little experience of quality systems in laboratories. The training of interns in medical biology but also of laboratory technicians could improve the quality of the results. The monitoring of internal quality controls should be carried out regularly by the biologists. The causes of errors should be investigated and corrective measures should be taken as appropriate.

CONCLUSION

The objective of this study was to evaluate the quality of the glucose analysis performed in the biochemistry laboratory of the University Hospital Center of Joseph Ravoahangy Andrianavalona during the on-call period. Coefficients of variation CV > 5,0 % were found in 50 % of the cases. Assessment of the accuracy of the measuring tool showed that the blood glucose measurement was generally within acceptable ranges. The Westgard rules were not always followed. The training of interns in medical biology, the regular monitoring of internal quality controls and the investigation of the causes of errors could improve the quality of the results.

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