Performance Evaluation of Two Haematology Analysers: the Sysmex KX-21 and the Beckman Coulter A^C.T diff

Ahmed Khaled FARES, BSc. DCBA

Senior Specialist in Diagnostic Haematology,
Haematology Department of Princess Iman Research and Laboratory Sciences Centre, Amman-11134- P. O. Box 340875, Jordan.

The purpose of this study was to evaluate the automated haematology analyser KX-21 manufactured by Sysmex Corporation, Japan and the haematology analyser Coulter A^C.T diff manufactured by Beckman Coulter Corporation, USA and to recommend the suitable one for armed forces hospitals and health centres in Jordan.

The evaluation included precision, linearity, and carryover, which were tested and compared to manufacturers' claimed levels. The correlation studies were carried out on a significant number of normal and abnormal specimens against results from Sysmex K-1000 and Sysmex SE-9000.

Precision: Coefficient of variation (CV) for each complete blood count (CBC) parameter and the three part differential count as measured by the KX-21 indicated acceptable performance whereas only the lymphocyte (LYMPH), monocyte (MONO), granulocyte (GRAN) parameters of A^C.T diff were within specifications.

Linearity: Linearity for all dilution sensitive parameters, white blood cell (WBC), red blood cell (RBC), hemoglobin (HGB), and platelets (PLT), on both analysers was acceptable.

Carryover: Carryover for total WBC, RBC, HGB, HCT, and PLT were within the manufacturers' specifications for the KX-21. The only result that exceeded the upper limit of acceptability was the PLT carryover on the A^C.T diff whereas the WBC, RBC, HGB, and hematocrit (HCT) were within the manufacturer's specifications.

Correlation coefficient: Correlation coefficient (r) values for most parameters were greater than 0.95 for the two analysers. However, there were areas in which their performance was less than optimal.

It was found that in addition to the scientific assessment carried out in this study, other important factors for full evaluation would make Sysmex KX-21 relatively superior. Those factors should be considered and followed as described by International Council for Standardization in Haematology (ICSH) and National Committee for Clinical Laboratory Standards (NCCLS) protocols.

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Key Words Automated Hematology Analyzer, KX-21, Coulter, A^C.T diff, Performance

INTRODUCTION

Complete blood count (CBC) and the differential white blood cell (WBC) count are the main tests used for routine haematology laboratory, which are carried out quantitatively by automated analysers in almost every modern laboratory.

At Princess Iman Research and Laboratory Sciences Centre, the haematology laboratory is the reference for all armed forces hospitals and health centres. This lab has two automated analysers, the Sysmex K-1000, and the Sysmex SE-9000, in addition to the Coulter T-660 for night duties.

In the year 1999, the Royal Medical Services Directorate ordered this department to put specifications for haematology analysers to supply and upgrade some of its hospitals and health centres laboratories with new automated analysers.

The main specifications included the following: throughput of 60 samples per hour, 18 parameters including three part differential count, sample volume of 100 microliters or less, quality control program, automatic cleaning, and use of two reagents. For that reason we evaluated four analysers, among those were the Sysmex KX-21 and the Coulter A^C.T diff.

The evaluation followed two protocols; The International Council for Standardization in Haematology (ICSH), and the National Committee for Clinical Laboratory Standards (NCCLS), [1, 2].

In this study the following three areas were evaluated:

1) The scientific assessment, which includes precision, linearity and carryover were tested and compared to manufacturer's claimed levels.
2) The correlation studies, which used a large number of residual specimens sent for analysis to the haematology laboratory and analysed on the K-1000 and then immediately tested each analyser independently.
3) Technological and general features

The ultimate objective of this study was to evaluate the two analysers to find the one, which meets our requirements.

MATERIALS AND METHODS

Instrumentation

Both analysers are fully automated with simultaneous analysis of 18 parameters including three cell distribution histograms for WBC, red blood cell (RBC) and platelet (PLT), which are printed and displayed by the KX-21, whereas they are only printed by the A^C.T diff.
The KX-21 identifies three WBC populations (Neutrophils (NEUT), Lymphocytes (LYMPH), and Mixed cells which, consist of Monocytes (MONO), Eosinophils (EO), in addition to Basophiles(BASO)), while the A^C.T diff identifies the Granulocytes (GRAN), LYMPH, and MONO.
Both of them use the technology of electrical impedance method of direct current. For haemoglobin (HGB) measurements, the KX-21 uses a non-cyanide haemoglobin method, while the A^C.T diff uses the traditional cyanmethaemoglobin method.

Scientific assessment

Precision studies
Precision was evaluated by performing 20 replicate analyses on normal control samples supplied by the analysers' representatives in three occasions during the evaluation period. Coefficient of variation (CV) was calculated for WBC, RBC, HGB, hematocrit (HCT), mean corpuscular volume (MCV), mean corpusculan hemoglobin (MCH), mean corpuscular hemoglobin concenteration (MCHC), PLT, and the WBC three part differential.

Linearity studies
Linearity was performed on directly measured parameters, and since HCT is a measured parameter by the KX-21, while is not by the A^C.T diff, this parameter was not included in these studies. The selected patient specimens were collected for each analyser, which covered the upper reportable range mainly for WBC and PLT in addition to their RBC and HGB. The dilutions of selected specimens were prepared using the specific diluents of each analyser and ranged from 10% to 100% in 10% intervals, and each dilution result was the mean value of three separate dilutions. The average of the three results was plotted against the dilution concentration and the slope and intercept were calculated for each parameter.

Carryover studies
Carryover was evaluated for total WBC, RBC, HGB, and PLT on each test instrument. Analysing high patients samples three consecutive times (i_1, i_2, i_3) followed immediately by low samples three consecutive times (j_1, j_2, j_3), performed the assessment. The carryover formula used was: $(j_1 - j_3) / (i_3 - j_3) \times 100\%$ as described by Shinton, England, and Kennedy[3].

Correlation studies
WBC, RBC, HGB, HCT, MCV, PLT, in addition to three part differential count were compared with results obtained by the K-1000, except for GRAN and MONO results obtained by the A^C.T diff which were compared to the results of GRAN (NEUT, EO, and BASO) and MONO obtained by the Sysmex SE-9000. The K-1000 was chosen as the reference analyser since it has almost similar technology as well as being previously evaluated in this department[4]. The SE-9000 was chosen as the reference for the comparison of GRAN and MONO since this analyser has the ability to perform the five differential count including the GRAN subgroups; NEUT, EO, and the BASO and showed excellent performance of WBC differential count[5].

Technological and the general features

Differences in specifications between the two analysers were inspected and were compared to supplier claimed specifications[6, 7].

RESULTS

Precision

All parameters were within the instrument precision specifications for the KX-21 whereas only the LYMPH, MONO, GRAN parameters of A^C.T diff were within specifications. Also, there were no instrument specifications for HCT, MCH and MCHC for the A^C.T diff. CV% is presented along with the instrument precision specifications in CV% as displayed in ***Table 1***.

Linearity

In ***Figs. 1 and 2*** the actual instrument results (Y-axis) were plotted against the dilutions concentration. The slopes and intercepts are also displayed.

Table 1 *Precision results*

KX-21

	WBC	RBC	HGB	HCT	MCV	MCH	MCHC	PLT	LYMPH	MXD	NEUT
CV (%)	1.57	0.55	0.81	0.61	0.23	0.94	1.10	3.13	2.48	5.52	1.44
Specs CV (%)	3.50	2.00	1.50	2.00	2.00	2.00	2.00	6.00	15.00	30.00	15.00

A^C.T diff

	WBC	RBC	HGB	HCT	MCV	MCH	MCHC	PLT	LYMPH (SD)	MONO (SD)	GRAN (SD)
CV (%)	2.20	1.71	1.83	1.67	0.48	1.48	1.59	3.68	1.70	4.57	1.72
Specs CV (%)	1.15	1.14	1.12	No specs	0.28	No specs	No specs	3.14	2.08	5.27	1.80

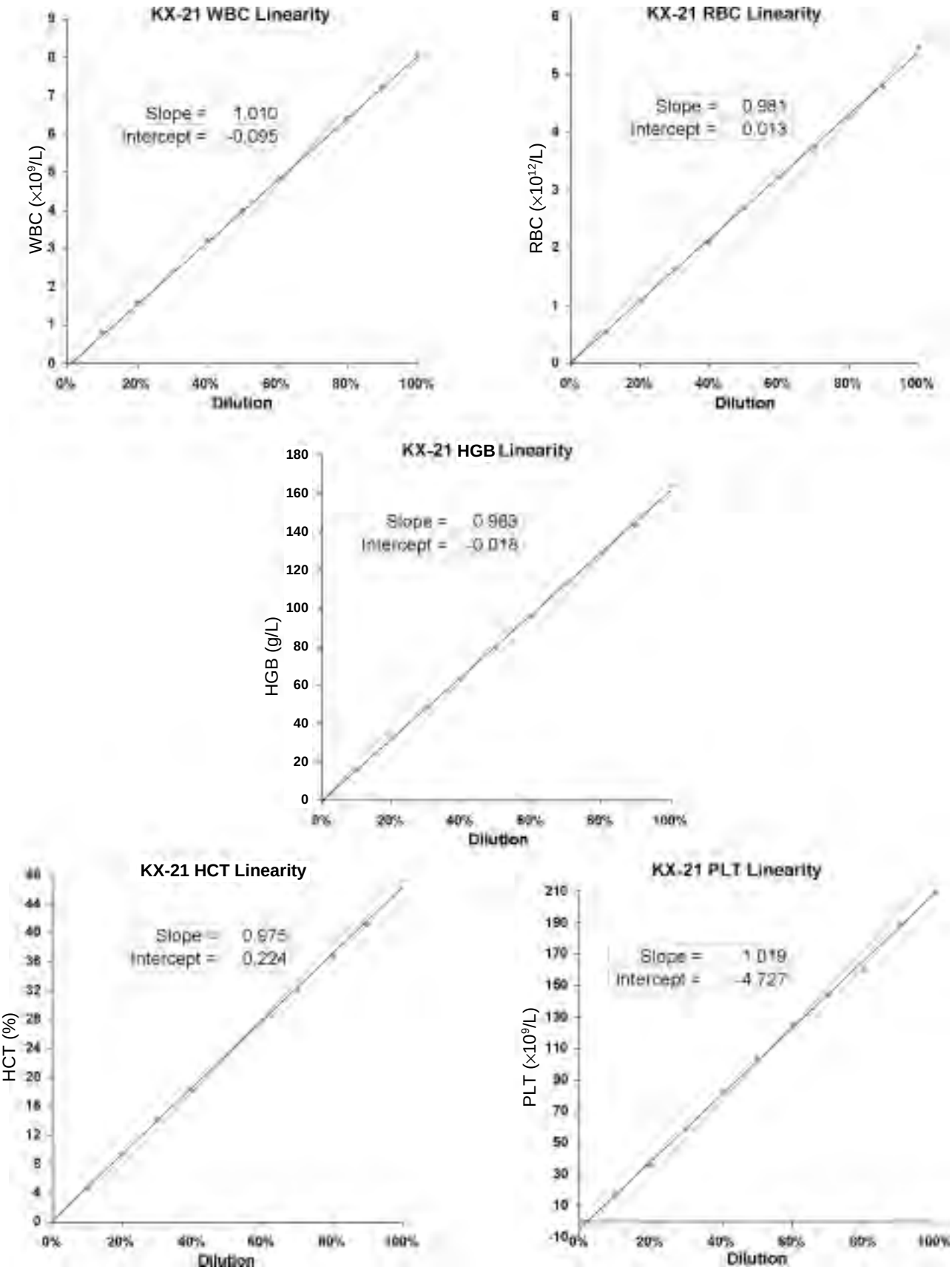

Fig. 1 *Results of linearity studies by KX-21*

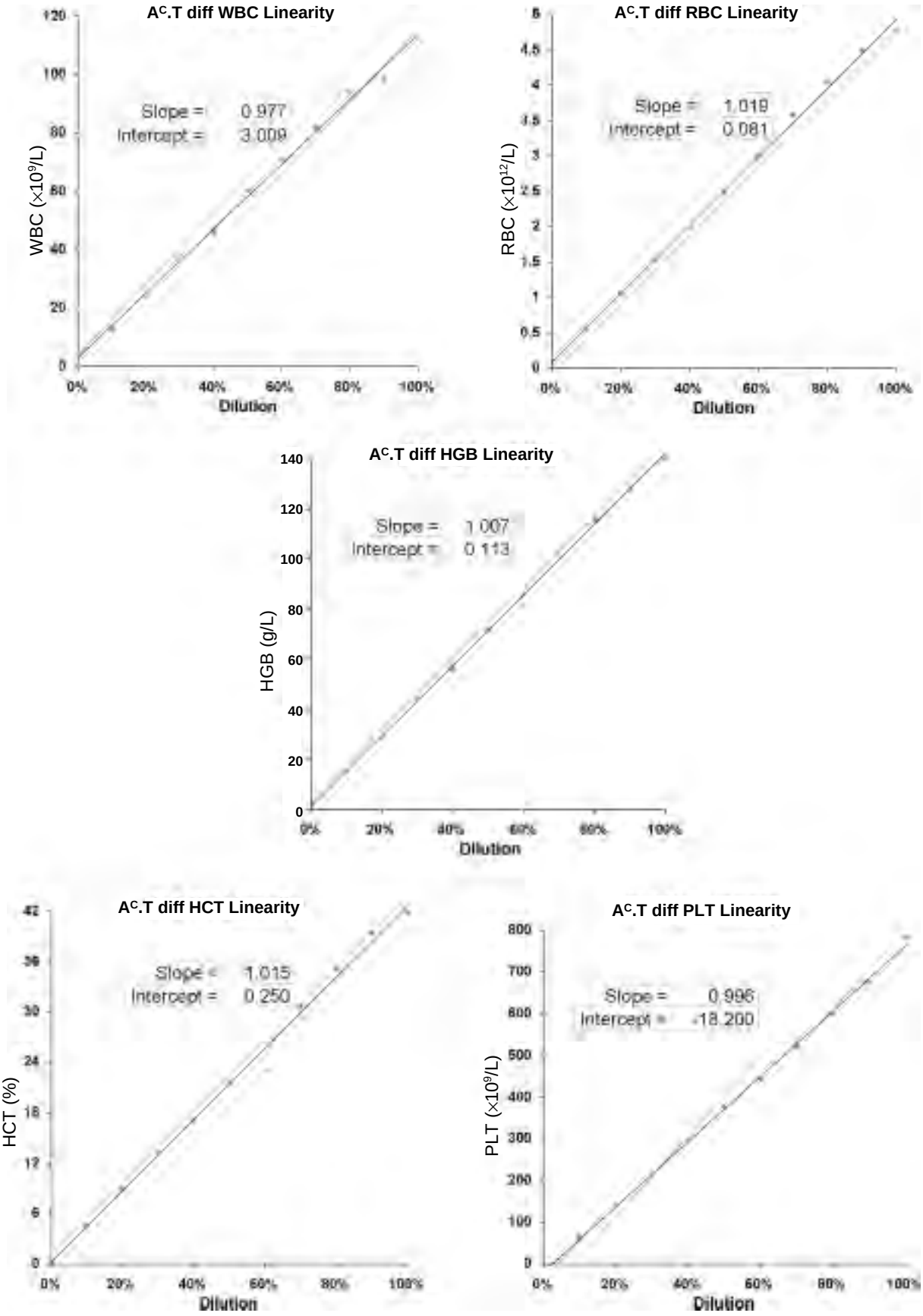

Fig. 2 *Results of linearity studies by A^C.T diff*

Carryover

Carryover data are presented in ***Table 2*** for total WBC, RBC, HGB, and PLT as measured on both analysers. The only result that exceeded the upper limit of acceptability was the PLT carryover on A^C.T diff. Carryover on both analysers for the remaining parameters were of negligible magnitude.

Correlation

The results of both analysers are displayed in ***Table 3***. Linear regression statistics were applied as shown in the table. The coefficient of correlation is greater than 0.95 for all parameters except for mixed cells on KX-21, which was 0.827 while the (r) values for MCV, MONO and GRAN on A^C.T diff were 0.876, 0.529, and 0.863, respectively.

Technological and general features

Table 4 shows the differences between the two analysers.

Table 2 *Carryover results*

KX-21

	WBC	RBC	HGB	PLT
CV (%)	0.10	0.20	0.87	0.43
Specs CV (%)	3.00	1.50	1.50	5.00

A^C.T diff

	WBC	RBC	HGB	PLT
CV (%)	0.00	1.43	1.12	4.34
Specs CV (%)	2.00	2.00	2.00	2.00

Table 3 *Correlation results*

KX-21

	WBC	RBC	HGB	HCT	MCV	PLT	LYMPH	MXD	NEUT
(r)	0.996	0.999	0.990	0.991	0.988	0.980	0.987	0.827	0.974
Slope	0.977	0.973	1.002	0.944	0.934	0.973	0.981	0.865	0.967
Intercept	– 0.039	0.038	0.041	1.168	5.091	– 10.506	0.470	3.236	0.212
No of Samples	395	394	395	396	397	395	381	285	282
X avg	8.165	4.384	12.071	37.201	85.246	253.668	29.280	9.155	62.231
Y avg	7.938	4.305	12.145	36.320	84.731	326.344	29.222	11.159	60.409

A^C.T diff

	WBC	RBC	HGB	HCT	MCV	PLT	LYMPH	MONO	GRAN
(r)	0.997	0.971	0.981	0.973	0.876	0.991	0.984	0.529	0.863
Slope	0.892	0.952	0.970	0.991	1.038	1.029	0.936	0.405	0.830
Intercept	0.660	0.140	0.262	0.088	– 2.997	– 8.423	2.301	3.897	9.531
No of Samples	231	241	241	241	241	241	221	218	220
X avg	9.084	4.124	11.610	34.583	84.394	273.398	32.257	8.000	61.766
Y avg	8.764	4.067	11.526	34.362	84.605	273.155	32.518	7.145	60.844

Table 4 *Differences between Sysmex KX-21 and Coulter A^C.T diff*

	KX-21	A^C.T diff
Differential parameters	NEUT, MXD, LYMPH	GRAN, MONO, LYMPH
Sample volume	50 microliter	12 microliter
HCT measurement	Yes	No
Calibration required	HGB and HCT	All parameters
HGB measurement	Non-cyanmethaemoglobin method	Cyanmethaemoglobin method
Sample per hour	60	45-50
Reagent level monitoring	By level sensors	By number of performed cycle
Display range:		
WBC	0.0 - 299.9	0.0 - 150
RBC	0.00 -19.99	0.00 - 8.00
PLT	0 - 1999	0 - 3000
Linearity limits:		
WBC	1.0 - 99.9	0.0 - 99.9
RBC	0.30 - 7.00	0.00 - 7.00
PLT	10.0 - 999	0.00 - 999
Data storage	240	250
Maintenance	Fully automated	Require user intervention
Operation by skilled person	No	Yes, need intervention to move From one set criteria to Another one
Quality control results	Displayed and printed	Not displayed but stored in the key card

DISCUSSION

All parameters were within the instrument precision specifications for the KX-21 whereas only the LYMPH, MONO, GRAN parameters of A^C.T diff were within specifications. Also, there were no instrument specifications for HCT, MCH and MCHC for the A^C.T diff. The precision for NEUT and GRAN and LYMPH proved to be excellent in both analysers.

The correlation and linear regression statistics of both analysers compared to the K-1000 and the SE-9000 showed excellent correlation and regression lines except for MCV and MONO on the A^C.T diff. For MONO this may depend on the low presence of this population in the examined sample. It also may depend on the difficulty the instrument may have had in determination of these cells[8], which reflects the poor correlation (r was 0.529 on the A^C.T diff).

The rejection rate in which the KX-21 failed to provide results on NEUT, mixed cells, and MONO were 29.8%, 29.1%, and 5.2%, respectively. Whereas, the proportion of cases in which the A^C.T diff failed to provide results on GRAN, MONO, and LYMPH were 8.7%, 9.5%, and 9.5%, respectively. A similar method was used by Bentley, et al[9].

Reviewing the blood films of these rejected samples showed that these difficult samples contained abnormal cells, which could emerge on another cell population. These cells were immature myeloid cells, NEUT showing toxic granulation with vaculation, blast cells, large atypical LYMPH, and PLT clumps.

We expect that these instruments will be run by non-skilled and or non-haematology technicians, therefore, these samples should be left for a senior technician who could assess them microscopically[10]. These cases were not included in the correlation studies.

All carryover ratios were well below the specifications on both analysers except for the PLT parameter on the A^C. T diff.

The desirable features based on the differences between the two analysers, which are summarised in ***Table 4*** showed that the KX-21 exceeded the A^C. T diff particularly with the non-cyanide method used in HGB measurement. The KX-21 has an advantage of using the reagent, STROMATOLYSER-WH, which has released in 1998 as the first reagent in the world to achieve the simultaneous measurement of HGB and WBC count[11].

Overall, the results obtained for various parameters on the KX-21 were compatible with other recently published literature with this analyser[12, 13].

Another important criterion in the final evaluation is the price, which is considered as one of the major local constraints in a country like Jordan. This criterion is evaluated by a purchasing committee who selects the instrument of choice and, unfortunately, sometimes the price become the only preference criterion while other laboratories give it 25% as a maximum percentage among other criteria[14].

In conclusion, the final report by the evaluator recommended the KX-21 as the analyser, which will fulfil our local requirements.

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