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Original Article

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Performance Comparison of Sysmex Hematology Analyzers XN-550 and XN-10

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Background: *Sysmex XN-L series (XN-550) was introduced globally in 2015 as compact automated analyzers that are suitable for small hospitals and physician clinics. This is the first US-based evaluation on XN-550. The principles of XN-550 are based on XN series functionality, operability and clinical parameters. The footprint of XN-L series is among the smallest and is equipped with advanced testing modalities including measurement of reticulocyte indices with the RET-He test, low white blood cell (LWBC) and body fluid modes in addition to conventional hematologic parameters.*

Methods: *Performance of the XN-550 was compared to high throughput automated analyzer XN-10, manual differential counts and morphology review using peripheral blood samples (n=207). Analytical performance, flagging performance, and precision were evaluated. Work flow was assessed.*

Results: *Deming regression and correlation of CBC parameters comparing XN-550 and XN-10 showed high correlation of 28 parameters (r=0.8275 to 0.9999). Notably, all the RBC-related parameters obtained from the RET channel as well as the platelet count (PLT) had high correlation. Flagging performance also showed high correlation. Work flow study revealed a throughput of 60 samples per hour.*

Conclusion: *The XN-550 has shown high correlation coefficient and excellent comparative performance when compared to XN-10. Our study demonstrated that XN-550 is highly reliable and comparable to XN-10 and thus could offer opportunity especially in small hospital laboratories and physician clinics. Moreover, XN-550 can be used as a backup system if a high volume analyzer of XN-series needs maintenance as well as for emergency situations.*

Key Words Hematology, Analyzer, Performance Evaluation, Flagging, Precision, Workflow, Body Fluid

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INTRODUCTION

The selection of an automated hematology analyzer has direct impact on the accuracy of patient results and laboratory efficiency. The XN-10 automated hematology analyzer (Sysmex Corporation, Kobe, Japan) has been thoroughly evaluated [1-8] to demonstrate that it is a highly reliable and robust system. The XN-10 is widely used in many high throughput laboratories throughout the world, and has customizable configurations including XN-1000, XN-3000, and XN-9000 systems. The XN-L series includes the XN-550 (Sysmex Corporation, Kobe, Japan), a compact analyzer that was developed based on the XN series functionality, operability, and clinical parameters. There are four channels for varies functionalities. WNR channel counts total white blood cells, detects abnormal white blood cells and platelet clumps, enumerates NRBCs, and with a nucleated red blood cell correction function. White blood cell differentiation (WDF) channel gives 6 WBC classifications. A third channel for reticulocyte counting (RET) is available with an optional license. A fourth channel abnormal cell detection (WPC) is unavailable in the Americas. The XN-550 is equipped with 28 parameters including conventional hematology parameters such as CBC parameters and WBC classifications as well as advanced parameters including reticulocyte (RET) measurement functions with reticulocyte hemoglobin equivalent (RET-He), nucleated red blood cell (NRBC) detection, and automated immature granulocyte count (IG; includes enumeration of metamyelocytes, myelocytes and promyelocytes). It also has the capability of advanced testing modes including low WBC (LWBC) mode and body fluid (BF) modes. The XN-550 has the added advantage of an automated Rerun/Repeat/Reflex and flagging functions.

Notes: This article is based on current regulatory requirements in the United States. (as of Oct. 2019)
The specifications, performances and functions described here may be different depending on the regions or the countries due to the regulatory affairs, legal matters or local guidelines. For more details, please contact your regional affiliates or distributors.

The XN-550 has a small footprint which makes it suitable for small hospital laboratories, physician offices labs, and as a backup analyzer for large laboratories.

Here we compared the analytic performance, throughput, and flagging performance of the Sysmex XN-550 analyzer to our routine hematology analyzer Sysmex XN-10, to determine whether the instrument meets the high quality standards to be reliably used in low-volume laboratories or as a backup system for the XN-series.

MATERIALS AND METHODS

Samples

Peripheral blood samples collected in K2 EDTA (n = 207) from a regional hospital were analyzed on both XN-10 and XN-550 within four hours of collection. Smears were made on each peripheral blood sample for manual differential count and morphologic review.

Samples were evaluated for study inclusion upon receipt in the laboratory. Special consideration was given to NRBCs, low platelets and immature or problematic WBCs (i.e., blasts, immature granulocytes, variant lymphocytes) as well as RBC variables (i.e., fragments, inclusions or hemoglobinopathy) in order to collect sufficient samples to represent various conditions. The pediatric population was not included in this study due to the fact that this institution is primarily an adult patient hospital. Normal/negative samples (n = 95) met the following criteria: 1) No clinical evidence of medical disorder known to affect WBC or differential count. 2) CBC parameters within normal range. 3) Normal serum chemistry values (if available). Abnormal samples (n = 112) represented various clinical conditions of platelet, white cell and red cell alterations.

Abnormal cell flagging

The instrument detects abnormal cell size, nuclear shape, and granularity in two standard channels (WNR on XN-10 and WDF on both XN-10 and XN-550). The WNR channel on XN-10 is used to detect platelet clumps, NRBCs, and abnormal WBCs. The WDF channel flags atypical lymphocytes and blasts/abnormal lymphocytes. Abnormal flagging performance was evaluated by comparing XN-10, XN-550, and manual review.

Workflow

The workflow on the XN-550 was evaluated by calculating samples/hour, after loading samples into multiple racks and analyzing results in auto-sampler mode.

Precision study

A precision study was conducted on 10 fresh whole blood samples from healthy individuals. The samples were analyzed 10 successive times on the XN-550 (using auto-sampler) within 4 hours of collection. The Coefficient of Variation (CV%) and Standard Deviation (SD) were calculated, according to ICSH guidelines.[9] The same 10 samples were also diluted (1:7) with CELLPACK diluent and analyzed 10 consecutive times in the Pre-Dilute (PD) mode on the XN-550 within 4 hours of collection. The CV% and SD were calculated and compared to data from the whole blood mode.

Statistical analysis

Regression statistics were calculated using the Deming method. With-in run precision and overall flagging performance were also calculated.

RESULTS

Comparative study

The results of analytic performance evaluation on blood specimens of the XN-550 (XN-L series) compared to XN-10 (XN series) are shown in ***Table 1***. All correlation results were excellent (R value > 0.9) except for the basophil percentage. Absolute reticulocyte number and immature reticulocyte fraction (IRF) had acceptable correlation with an R value of 0.89 and 0.82, respectively. Representative scatter plots including WBC, red blood cells (RBC), hemoglobin (HGB), and immature granulocyte count (IG) on XN-10 and XN-550 are illustrated in ***Fig. 1***.

The results of the XN-550 performance on white cell differential counts compared to manual differential are shown in ***Table 2***. Correlation of neutrophil and lymphocyte percentage was excellent. The correlation of monocytes, eosinophils, and immature granulocytes was acceptable. However the basophil correlation was poor, which may be due to a very low cell incidence.[10-11]

Abnormal flagging study

The correlation coefficient of flagging comparison was high among the XN-10, the XN-550, and the manual differential (R values > 0.9). The three most commonly flagged parameters are blasts/abnormal lymphocytes flag, immature granulocyte (IG), and NRBCs. ***Table 3*** illustrates IG, NRBC, and Blast/Abnormal lymphocyte flagging comparison study results.

A few minor observations are noted but the numbers are small and do not reach statistical significance. The XN-10 has slightly more NRBC flags but the XN-550 flagging was highly correlated with the manual differential on NRBC. The XN-550 flagged fragmented RBC in one case and upon morphologic review the presence of scattered schistocytes was confirmed. Another case in which no red blood cell morphology was flagged by the instruments but there was anisopoikilocytosis and occasional schistocytes

Table 1 *Overall evaluation performance on blood specimens (n=207) of XN-550 compared to XN-10*

Parameter	Range	Correlation (r^2)	Slope	Intercept
WBC	0.120–275.49	0.9999	0.969	0.2111
RBC	1.560–7.140	0.9982	0.991	0.0218
HGB	5.2–19.1	0.9981	1.004	0.18
HCT	16.1–60.7	0.9978	0.973	0.43
MCV	66.90–131.50	0.9933	1.019	-2.742
MCH	18.0–42.3	0.9908	1.022	0.03
MCHC	26.5–38.5	0.9418	0.975	1.96
PLT	7–1449	0.9971	0.965	7.4
RDW-SD	37.0–100.4	0.9952	0.992	-0.24
RDW-CV	11.9–30.1	0.9989	0.984	0.05
MPV	8.7–13.8	0.9430	0.957	0.19
NEUT#	0.16–34.07	0.9989	0.995	-0.004
LYMPH#	0.08–266.89	0.9999	0.970	0.103
MONO#	0.01–2.82	0.9507	1.021	-0.022
EO#	0.00–1.04	0.9902	0.984	0.004
BASO#	0.00–1.38	0.9166	0.511	0.008
IG#	0.00–5.53	0.9921	0.930	-0.018
NEUT%	2.70–94.70	0.9966	0.992	0.328
LYMPH%	2.5–96.9	0.9963	0.993	0.62
MONO%	0.3–34.4	0.9793	0.972	0.13
EO%	0.0–12.7	0.9836	1.015	0.04
BASO%	0.0–7.4	0.4906	0.509	0.16
IG%	0.0–18.6	0.9506	0.867	-0.12
RET#	0.031–0.282	0.8909	0.932	-0.01234
RET%	0.27–8.74	0.9920	0.921	-0.262
IRF	4.8–54.4	0.8275	1.005	-0.27
RET-He	22.0–45.3	0.9517	0.966	-3.18

WBC, white blood cell count; RBC, red blood cell count; HGB, hemoglobin; HCT, hematocrit; MCV, mean cell volume; MCH, mean corpuscular hemoglobin; MCHC, mean corpuscular hemoglobin concentration; PLT, platelet count; RDW-SD, red cell distribution width standard deviation; RDW-CV, red cell distribution width correlation coefficient; MPV, mean platelet volume; NEUT# absolute neutrophil count; LYMPH#, absolute lymphocyte count; MONO#, absolute monocyte count; EO# absolute eosinophil count; BASO#, absolute basophil count; IG#, absolute immature granulocyte count; NEUT%, neutrophil percentage; LYMPH%, lymphocyte percentage; MONO%, monocyte percentage; EO%, eosinophil percentage; BASO% basophil percentage; IG%, immature granulocyte percentage; RET#, absolute reticulocyte count; RET%, reticulocyte percentage; IRF, immature reticulocyte fraction; RET-He, reticulocyte hemoglobin.

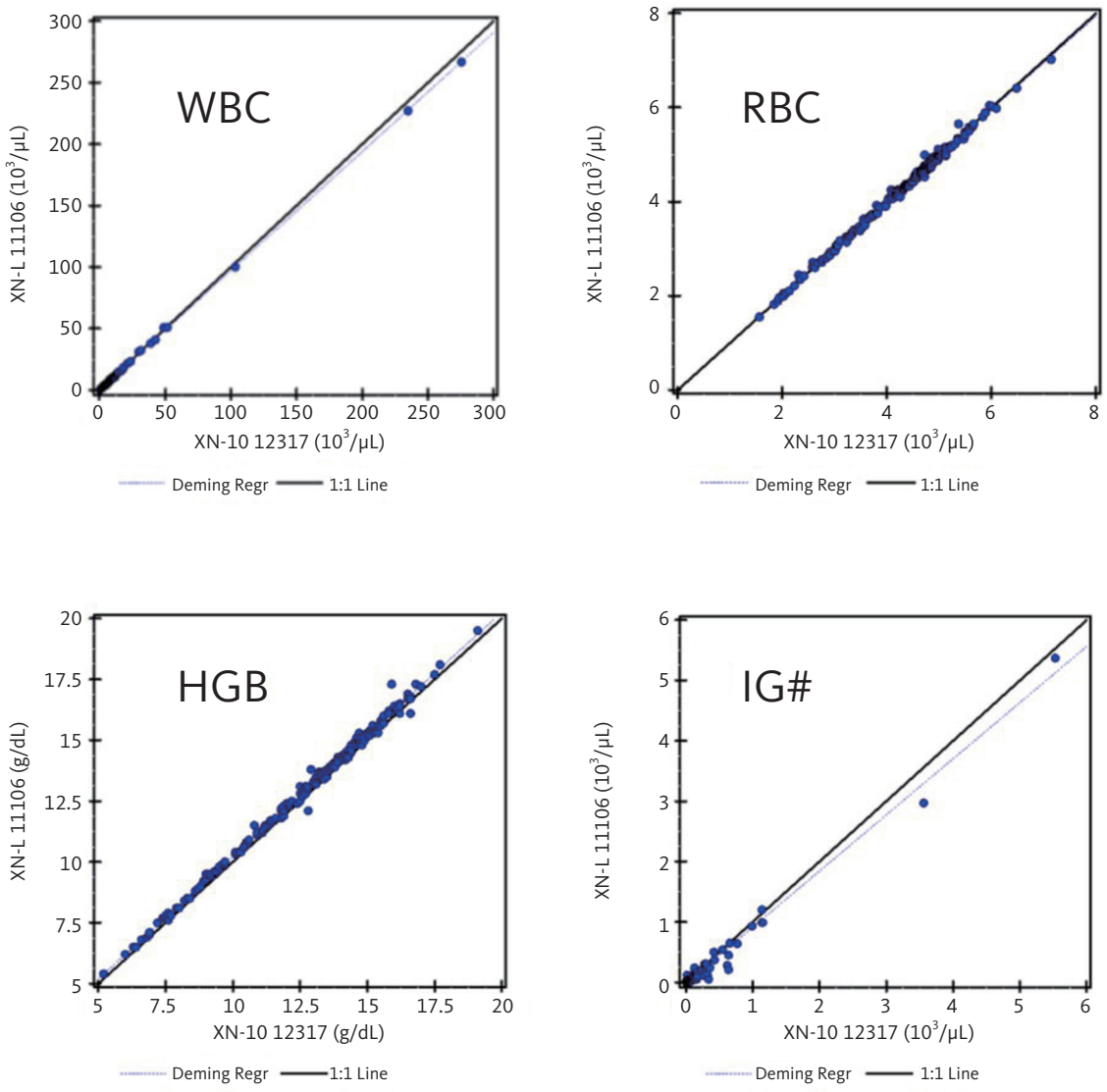

Fig. 1 *Representative scatter plots including WBC, RBC, HGB, and immature granulocyte (IG) count on XN-10 and XN-550*

Table 2 *Performance comparison of white cell differential on XN-550 and manual differential*

Parameter	Range	Correlation (r^2)	Slope	Intercept
NEUT%	2.50–96.30	0.9756	1.002	0.342
LYMPH%	1.75–96.75	0.9783	0.997	-1.952
MONO%	0.00–23.75	0.8107	1.481	-1.631
EO%	0.0–11.75	0.8776	1.183	-0.253
BASO%	0.0–8.50	0.4609	1.251	-0.394
IG%	0.0–7.75	0.8164	2.604	0.286

NEUT%, neutrophil percentage; LYMPH%, lymphocyte percentage; MONO%, monocyte percentage; EO%, eosinophil percentage; BASO% basophil percentage; IG%, immature granulocyte percentage.

Table 3 *Representative flagging comparison among XN-10, XN-550, and manual differential*

Flags	XN-10 (# cases)	XN-550 (# cases)	Manual (# cases)
IG	22	20	21
NRBC	14	8	9
Blasts/Abn Lymphs	27	30	26
Correlation coefficient:	**0.983671**	**Manual vs XN-550**	
	0.994909	**Manual vs XN-10**	
	0.996800	**XN-10 vs XN-550**	

Note: total case flagged N = 108
IG, immature granulocyte; NRBC, nucleated red blood cell; Abn Lymphs, abnormal lymphocytes.

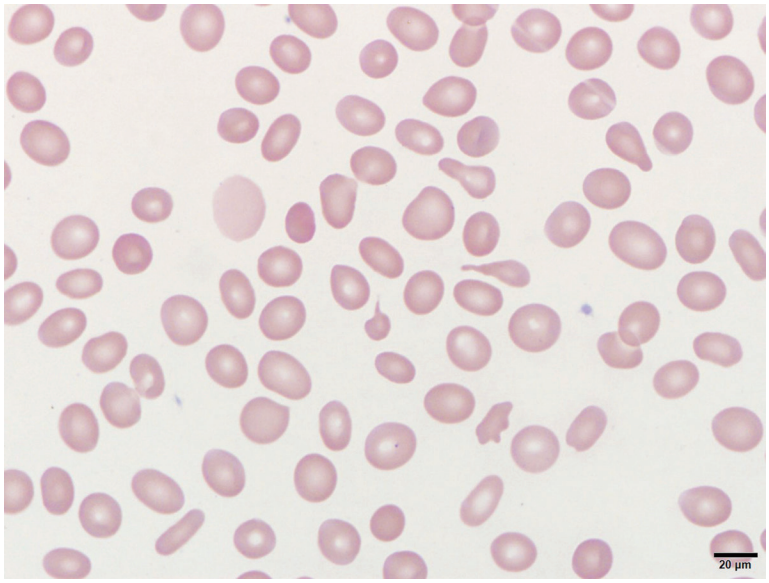

Fig. 2 *Marked anisopoikilocytosis on the peripheral blood review. Both XN-10 and XN-550 failed to flag anisopoikilocytosis in this case.*

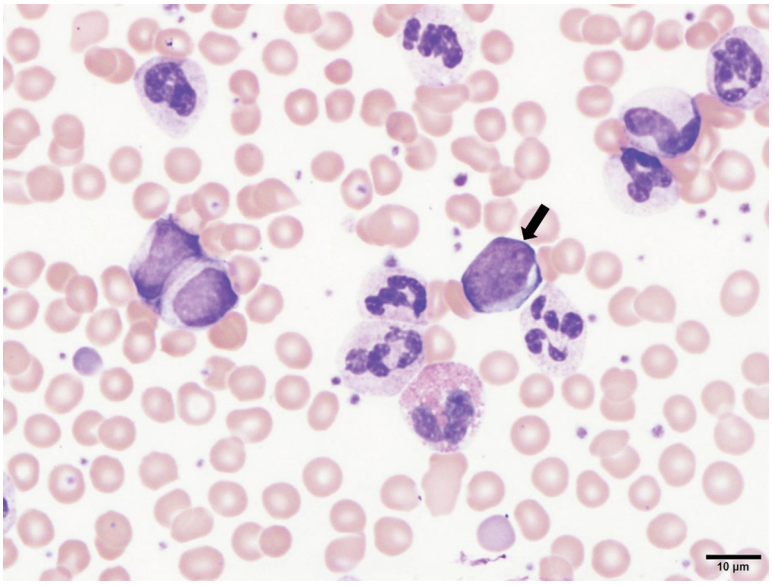

Fig. 3 *Marked left shift and frequent immature granulocytes are illustrated in this image. A single blast is also present. Both XN-10 and XN-550 enumerated approximately 50% immature granulocytes in this case, high correlate with manual differential count.*

upon morphologic review (***Fig. 2***). A case of cold agglutinin was not flagged by both instruments. A representative image of the immature granulocytes and blast is shown in ***Fig. 3***. In this case the IG was approx. 50% on both the XN-10 and the XN-550, illustrating high correlation among the XN-10, XN-550, and manual differential count.

Work flow study

The workflow study showed that the XN-550 is capable of running 60 samples per hour. The instrument was easy to use. There were no issues or problems encountered in auto or manual mode during validation.

Precision study

The precision results on all CBC parameters from 10 patients were excellent and well below manufacturer's specifications, except the basophil count. The CBC precision study results are listed in ***Table 4***.

DISCUSSION

This is the first US-based evaluation that is specific to the US market. The Sysmex XN-550 analyzer has a compact footprint, is suitable for small hospital laboratories, clinician offices, and as a backup for higher volume systems such as the XN series. It offers a throughput of 60 samples an hour. It has the capability to test routine hematology parameters as well as advanced hematology testing including reticulocyte parameters with reticulocyte hemoglobin, immature granulocyte enumeration, NRBC flagging, as well as low WBC and body fluid modes.

The XN-550 has shown high correlation coefficient and excellent comparative performance in all WDF+RET parameters including 8 red blood cell parameters (RBC, HGB, HCT, MCV, MCH, MCHC, RDW-SD, RDW-CV), 6 WBC parameters (WBC, NEUT, LYMPH, MONO, EO, BASO), two platelet parameters (PLT, MPV), and 4 advanced hematology parameters (IG, RET, IRF, RET-He). Platelets are measured by impedance method, not PLT-O as it was in the European market. The basophil percentage showed poor correlation coefficient of 0.4906. It may be related to different testing methodology used by XN-550 and XN-10. Basophils are directly measured in the WNR channel on XN-10 but on XN-550 (and all other XN-L) they are measured in the WDF channel. In addition, the incidence of basophil is extremely low in most samples (range 0.0 to 7.4%). These findings are consistent with previous studies.[11, 12]

Advanced clinical parameters including immature granulocyte count (IG) and reticulocyte hemoglobin equivalent (RET-He) can be measured on the XN-550. An automated IG provides a standardized measurement of immature cells including metamyelocytes, myelocytes, and promyelocytes. The RET-He measures the amount of hemoglobin in the young reticulocytes and is a measure of erythropoiesis. This parameter is not an acute phase reactant as are some parameters which assess red cell production.

The overall flagging comparison was excellent among the XN-10, the XN-550, and the manual differential. Blasts/abnormal lymphocytes flagging performance was excellent with only two cases missed in a total of 32 analyzed cases.

Table 4 *Precision study with whole blood samples*

	WBC	RBC	HGB	HCT	MCV	MCH	MCHC	PLT	RDW-SD	RDW-CV	MPV
Run #1	7.61	4.79	13.90	40	83.5	29.0	34.8	372	42.4	13.7	10.9
Run #2	7.76	4.76	13.90	39.8	83.6	29.2	34.9	369	42.9	13.8	10.5
Run #3	7.75	4.77	13.90	39.9	83.6	29.1	34.8	364	42.5	13.7	10.7
Run #4	7.65	4.73	13.80	39.6	83.7	29.2	34.8	372	42.2	13.7	10.8
Run #5	7.78	4.69	13.70	39.3	83.8	29.2	34.9	379	42.7	13.9	10.8
Run #6	7.63	4.78	13.70	40	83.7	28.7	34.3	369	43.1	13.8	10.7
Run #7	7.46	4.65	13.60	39.1	84.1	29.2	34.8	358	42.7	13.8	10.5
Run #8	7.46	4.6	13.60	38.7	84.1	29.6	35.1	365	42.4	13.8	10.6
Run #9	7.50	4.6	13.40	38.7	84.1	29.1	34.6	368	42.9	13.8	10.8
Run #10	7.62	4.66	13.60	39.3	84.3	29.2	34.6	370	43.0	13.9	11.2
Mean	**7.62**	**4.70**	**13.7**	**39.4**	**83.9**	**29.2**	**34.8**	**369**	**42.7**	**13.8**	**10.8**
SD	**0.11**	**0.07**	**0.16**	**0.47**	**0.26**	**0.21**	**0.21**	**5.30**	**0.28**	**0.07**	**0.20**
CV%	**1.49**	**1.47**	**1.15**	**1.20**	**0.31**	**0.72**	**0.59**	**1.44**	**0.66**	**0.51**	**1.83**

WBC, white blood cell count; RBC, red blood cell count; HGB, hemoglobin; HCT, hematocrit; MCV, mean cell volume; MCH, mean corpuscular hemoglobin; MCHC, mean corpuscular hemoglobin concentration; PLT, platelet count; RDW-SD, red cell distribution width standard deviation; RDW-CV, red cell distribution width correlation coefficient; MPV, mean platelet volume.

This finding was consistent with previous studies.[2,5,13] Hotton et al. found that the XN-10 did not miss circulating blasts. Bruegel et al. reported a blast detection sensitivity of 97%.[5]

The XN-550 showed high correlation on NRBC detection when compared with manual review. This finding is consistent with previous studies. Tantanate et al. found that the automated NRBC enumeration by XN was precise and could replace the traditional manual count, especially for the specimens with NRBCs lower than 200%.[14] Hotton et al. demonstrated an NRBC detection sensitivity of 90% on the XN-10 analyzer.[2]

The XN-550 flagged fragmented RBC in one case. Morphologic review confirmed the presence of scattered schistocytes. One case was not flagged but there was significant anisopoikilocytosis and occasional schistocytes present. Lesesve et al. studies established a fragmented red cell reference range for the XN-10.[15] But no such study on XN-550 could be found in the literature. Therefore, the sensitivity and specificity of detecting fragmented RBCs need to be defined in future evaluations.

The body fluid performance on XN-550 showed a very high correlation coefficient (0.9587 to 0.9994) for all BF parameters (WBC-BF, RBC-BF, TC-BF, MN#, PMN#, MN%, PMN%) and all body fluid types (ascites, synovial fluids, pleural fluids, and cerebrospinal) when compared to the XN-10 (data not shown). These findings are consistent with other studies.[16] Performance of XN-10 on ascites/peritoneal, pleural, cerebrospinal, and synovial fluids has been extensively studied previously.[4,17,18] Our current study confirmed that XN-L systems have excellent performance on body fluids and are a reliable alternative to other methods.

Limitation of this study includes too few low WBC count samples. We only collected 3 samples with WBC count less than $0.5 \times 10^3/\mu L$. Although the correlation of the three sample is excellent, the sample size is too small for statistical analysis. The other limitation is body fluids study. We collected 22 body fluid samples during this collection period. Again the samples showed excellent correlation on all parameters between XN-10 and XN-550, however, the sample size for each type of body fluid was insufficient for statistical analysis.

In summary, this is the first US-based evaluation on XN-550 that is specific to the US market and our study demonstrated that the XN-550 is highly reliable with functionality comparable to the XN-10 analyzer. Thus it can offer opportunity especially in small hospital laboratories, satellite labs, and physician clinics. Moreover, the XN-550 can be used as a backup system if a high volume analyzer such as the Sysmex XN-series needs maintenance as well as in emergency situations.

References

1) *Briggs C, Longair I, Kumar P, Singh D, Machin SJ. Performance evaluation of the Sysmex haematology XN modular system. J Clin Pathol. 2012;65(11): 1024-30.*
2) *Hotton J, Broothaers J, Swaelens C, Cantinieaux B. Performance and abnormal cell flagging comparisons of three automated blood cell counters: Cell-Dyn Sapphire, DxH-800, and XN-2000. Am J Clin Pathol. 2013;140(6):845-52.*
3) *Seo JY, Lee ST, Kim SH. Performance evaluation of the new hematology analyzer Sysmex XN-series. Int J Lab Hematol. 2015;37(2):155-64.*
4) *Tanaka Y, Matsushita H, Tanaka Y, Maruki Y, Kondo T, Asai S, Miyachi H. Evaluation of the body fluid mode of automated hematology analyzer XN-series for extremely low peripheral white blood cell counts. Int J Lab Hematol. 2014;36(1):e3-7.*
5) *Bruegel M, Nagel D, Funk M, Fuhrmann P, Zander J, Teupser D. Comparison of five automated hematology analyzers in a university hospital setting: Abbott Cell-Dyn Sapphire, Beckman Coulter DxH 800, Siemens Advia 2120i, Sysmex XE-5000, and Sysmex XN-2000. Clin Chem Lab Med. 2015;53(7):1057-71.*
6) *Kim H, Hur M, Choi SG, Oh KM, Moon HW, Yun YM. Comparison of white blood cell counts by WNR, WDF, and WPC channels in Sysmex XN hematology analyzer. Int J Lab Hematol. 2015;37(6):869-75.*
7) *Buoro S, Mecca T, Seghezzi M, Manenti B, Azzarà G, Dominoni P, Crippa A, Ottomano C, Lippi G. Analytical comparison between two hematological analyzer systems: CAL-8000 vs. XN-9000. Int J Lab Hematol. 2017;39(2):147-162.*
8) *Ciepiela O, Kotuła I, Kierat S, Sieczkowska S, Podsiadłowska A, Jenczelewska A, Księżarczyk K, Demkow U. A Comparison of Mindray BC-6800, Sysmex XN-2000, and Beckman Coulter LH750 Automated Hematology Analyzers: A Pediatric Study. J Clin Lab Anal. 2016;30(6):1128-1134.*
9) *International Council for Standardization in Haematology, Writing Group., Briggs C, Culp N, Davis B, d'Onofrio G, Zini G, Machin SJ; International Council for Standardization of Haematology. ICSH guidelines for the evaluation of blood cell analysers including those used for differential leucocyte and reticulocyte counting. Int J Lab Hematol. 2014;36(6):613-27.*
10) *Jo SY, Park SH, Kim IS, Yi J, Kim HH, Chang CL. Performance evaluation of recently launched Sysmex XN-550 Automatic Hematology Analyzer. Int J Lab Hematol. 2017;39(1):e4-e9.*
11) *Geara C, Cornet E, Troussard X. Comparative study of quantitative performances between the new Sysmex XN-L (XN-550) haematology analyser and the XN-9000 in a routine laboratory. Int J Lab Hematol. 2016;38(1):e10-1.*
12) *Tanaka M, Shukuya KI, Morita Y, et al. Performance Evaluation of the XN-550 Automated Hematology Analyzer Body Fluid Mode: Considerations for Operational Conditions for Cell Counting with Cerebrospinal and Synovial Fluids. Sysmex Journal International. 2016;26(1):1-9.*
13) *Becker PH, Fenneteau O, Da Costa L. Performance evaluation of the Sysmex XN-1000 hematology analyzer in assessment of the white blood cell count differential in pediatric specimens. Int J Lab Hematol. 2016;38(1):54-63.*
14) *Tantanate C, Klinbua C. Performance evaluation of the automated nucleated red blood cell enumeration on Sysmex XN analyser. Int J Lab Hematol. 2015;37(3):341-5.*
15) *Lesesve JF, Speyer E, Perol JP. Fragmented red cells reference range for the Sysmex XN®-series of automated blood cell counters. Int J Lab Hematol. 2015;37(5):583-7.*
16) *Tanaka M et al. Evaluation of the Automated Hematology Analyzer XN-550 for Cerebrospinal Fluid cell count. Japanese Journal of Medical Technology. 2015; 64(6): 749-754.*
17) *Genc S, Dervisoglu E, Omer D, Kucukates E, Omer B, Ademoglu E. Evaluation of Cell Counting in Body Fluids: Comparison of Two Automated Hematology Analyzers with Manual Microscopy. Clin Lab. 2016;62(12):2449-2453.*
18) *Seghezzi M, Buoro S, Manenti B, Mecca T, Ferrari R, Zappalà G, Castelli CC, Balboni F, Pezzati P, Ottomano C, Lippi G. Optimization of Cellular analysis of Synovial Fluids by optical microscopy and automated count using the Sysmex XN Body Fluid Mode. Clin Chim Acta. 2016;462:41-48.*