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Original Research Article

COMPARISON BETWEEN BODY FLUIDS CELL COUNTING ON SYSMEX MACHINE (XN550) VS MANUAL COUNT

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ABSTRACT

Background: The study compared body fluid cell counts generated by the Sysmex XN-550 analyzer with those obtained by conventional manual microscopic examination. **Materials and Methods:** This observational comparative study was conducted over 24 months at the Central Clinical Laboratory, Department of Pathology, Dr. Vasantrao Pawar Medical College and Hospital, Nashik. A total of 200 body fluid specimens were examined, including 100 cerebrospinal fluid (CSF) and 100 pleural fluid samples. Eligible specimens were tested by both the body-fluid mode of the Sysmex XN-550 and the conventional manual microscopic method. The following parameters were assessed: white blood cell (WBC) count, red blood cell (RBC) count, polymorphonuclear (PMN) cell percentage, mononuclear (MN) cell percentage, and high-fluorescence (HF) cell percentage. Pearson 's correlation coefficients were used to determine the relationship between the measurements obtained by the automated and manual methods. **Result:** In CSF, the two methods showed strong correlations for WBC count (r = 0.9998), RBC count (r = 0.9999), PMN percentage (r = 0.9940), and MN percentage (r = 0.9446). The correlation for the HF cells was poor (r = −0.0475). Pleural fluid also showed strong correlations with WBC count (r = 0.9776), RBC count (r = 0.9999), PMN percentage (r = 0.9977), MN percentage (r = 0.9941), and HF cells (r = 0.8723). **Conclusion:** The Sysmex XN-550 showed strong correlation with manual microscopy for routine WBC and RBC enumeration and for PMN and MN differential counts in both CSF and pleural fluid. These findings suggest that the analyzer can support rapid routine body fluid testing and may help improve the laboratory workflow. Nevertheless, microscopic examination remains necessary when abnormal or malignant cells are suspected, and when HF-cell findings require further evaluation.

INTRODUCTION

Body fluid cell counts and differential examination provide clinically useful information for diagnosis, treatment, and follow-up across many pathological conditions.[1] Cytological assessment of these specimens includes enumeration of WBCs and RBCs and differentiation of leukocytes into PMN and MN populations.[2] Modern hematology analyzers use optical and/or impedance-based technologies to automatically detect and count cells.[3] CSF and pleural fluid may contain leukocytes as well as mesothelial cells, macrophages, malignant cells, and other non-hematopoietic populations. These cells can contribute to the total nucleated cell count and therefore require appropriate interpretation.[4]

Abnormal leukocyte numbers in body fluids may be accompanied by inflammatory, infectious, and malignant diseases. Consequently, total WBC and differential counts, including neutrophils, lymphocytes, monocytes, and eosinophils, can provide important diagnostic information and may affect treatment and follow-up decisions.[5] Body fluid counts are useful for assessing infection, inflammation, hemorrhage, neoplasia, and other disorders affecting body cavities.[6]

CSF analysis is important in the investigation of neurological disorders. Changes in CSF composition, cellularity, pressure, and flow may occur in infectious, inflammatory, malignant, and other neurological conditions.[7] An elevated CSF WBC count may be observed in meningitis, encephalitis,

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and leukemic or malignant infiltration.[8] CSF is usually obtained by lumbar puncture, and its interpretation should be integrated with biochemical, microbiological, immunological, and cytological findings.

Pleural fluid occupies the potential space between the visceral and parietal pleura and permits smooth respiratory movement. Disturbances in pleural fluid formation or removal can lead to pleural effusion. The causes include congestive heart failure, pulmonary embolism, infection, malignancy, hemorrhage, inflammatory disease, and impaired lymphatic drainage. Pleural fluid cell counts and differential analysis can therefore contribute to determining the underlying disease process.

Traditionally, body fluid cell counts have been performed manually using a hemocytometer or Neubauer chamber, while differential counts are usually assessed on stained cytological preparations. Although manual microscopy remains an important reference technique, it is labor-intensive, time-consuming, and subject to analytical and inter-observer variation.[9] Automated hematology analyzers equipped with dedicated body-fluid modes offer an alternative that can facilitate faster and more standardized counting. The Sysmex XN-550 includes a body-fluid application intended to address some of the limitations of conventional manual testing.[10]

Body fluid analysis can be performed using manual microscopy, automated flow cytometry, or automated impedance/optical approaches. Manual microscopy has traditionally served as the reference method, whereas automation can increase analytical efficiency, shorten the turnaround time, and reduce inter-observer variation. Prompt processing is particularly important for body fluids because cells may deteriorate during prolonged storage.[11] Automated testing may consequently improve laboratory productivity and precision while decreasing the workload associated with manual counting.

Automated body fluid testing also has important limitations. The accuracy may decrease at very low cell concentrations, and atypical or malignant cells may not be classified reliably. Non-cellular materials, such as bacteria, lipids, crystals, proteinaceous material, and cellular debris, can also interfere with analysis. Thus, automated testing cannot be regarded as a complete substitute for microscopic examination in every clinical situation. The present study compared Sysmex XN-550 body-fluid analysis with conventional manual counting in CSF and pleural fluid.

MATERIALS AND METHODS

Study design and setting: This observational comparative study was conducted over 24 months, from September 2022 to August 2024, in the Central Clinical Laboratory, Department of Pathology, Dr. Vasantrao Pawar Medical College and Hospital, Nashik, Maharashtra, India. Institutional Ethics Committee approval was obtained before the study. A total of 200 body fluid specimens were included, consisting of 100 CSF and 100 pleural fluid samples. The study compared the results generated by the Sysmex XN-550 body fluid mode with conventional manual microscopic measurements.

Study population and sample size: The study included CSF and pleural fluid specimens received in the central clinical laboratory for routine diagnostic assessment during the study period. The sample size was calculated using a formula for comparison of two means, with alpha = 0.01, statistical power of 99% (beta = 0.01), a group ratio of 1, a mean of 41.1 for group 1 and 22.8 for group 2, and standard deviations of 25.2 and 22.8, respectively. The estimated requirement was 200 samples; accordingly, 100 CSF and 100 pleural fluid specimens were included.

Eligibility Criteria: All CSF and pleural fluid specimens received during the study period were considered eligible when they met the study requirements. Specimens were excluded if they were clotted, inadequate in volume, markedly blood-stained, or delayed sufficiently to affect cellular integrity or counting accuracy. Samples lacking sufficient material for both automated and manual examination were also excluded.

Samples with inadequate volume, marked blood contamination, or significant processing delays that could compromise cellular integrity or counting accuracy were excluded.

Data Collection: Age, sex, clinical diagnosis, or the indication for body fluid examination were obtained from laboratory requisition forms and available clinical records. Information was entered into a structured data-collection format. Each specimen received a study identification number, and automated and manual results were documented for subsequent statistical analysis.

Cerebrospinal Fluid Collection and Processing: CSF was collected by lumbar puncture by experienced physicians under aseptic conditions according to standard institutional practice. Patients were positioned in the lateral decubitus or sitting position as clinically appropriate. The specimen was collected in sterile containers, and an aliquot was transferred into an EDTA tube for cellular analysis. Samples were transported promptly to the Central Clinical Laboratory and processed as soon as possible to minimize cellular degeneration. Markedly blood-contaminated samples resulting from traumatic lumbar puncture were considered according to the predefined exclusion criteria.

Pleural Fluid Collection and Processing: Pleural fluid was collected by thoracentesis under appropriate aseptic precautions. Patients were positioned suitably, generally sitting upright with slight forward leaning, and imaging guidance was used when clinically indicated. The specimen was transferred to appropriate containers, including an EDTA tube for cellular analysis, and immediately transported to the laboratory. Prompt processing was

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performed to minimize cellular degeneration and morphological changes.

Manual Cell Counting: Manual counting was performed with an improved Neubauer counting chamber using conventional light microscopy. Total WBC and RBC counts were determined for both CSF and pleural fluid and reported as cells per microliter. For differential analysis, specimens were centrifuged and stained with Fields stain. Up to 100 cells were evaluated when adequate cellularity was present, and the differential was expressed as PMN and MN percentages.

Automated Cell Counting Using the Sysmex XN-550: The Sysmex XN-550 hematology analyzer (Sysmex Corporation, Kobe, Japan) was used in body-fluid mode for automated analysis. CSF and pleural fluid specimens were assessed for WBC and RBC counts and for PMN, MN, and HF-cell populations. Automated results were recorded alongside the corresponding manual microscopic findings. Analyzer flags or error messages suggesting interference or abnormal cellular populations were also noted during interpretation.

Study Variables: The main study variables were WBC count, RBC count, PMN percentage, MN percentage, and HF-cell percentage in CSF and pleural fluid. The principal analytical comparison was between automated testing with the Sysmex XN-550 and manual microscopic counting.

Age, sex, body fluid type, and underlying clinical diagnosis were recorded as additional variables.

Statistical Analysis: Data were entered into a Microsoft Excel spreadsheet and analyzed using appropriate statistical software. Continuous variables were summarized by mean, standard deviation, minimum, and maximum. Automated Sysmex XN-550 measurements were compared with manual microscopic results. Pearson's correlation coefficient was used to assess the relationship between the two methods for WBC, RBC, PMN, MN, and HF-cell measurements. A p-value of <0.05 was considered statistically significant. Results were presented in tables and scatter plots.

Ethical Considerations: The study was performed after approval from the Institutional Ethics Committee of the study institution and involved body fluid specimens submitted for routine clinical evaluation.

Patient information was kept confidential, and the analysis was performed without disclosure of personally identifiable information.

RESULTS

The study included 200 body fluid specimens: 100 CSF and 100 pleural fluid samples. Every sample was analyzed using both the Sysmex XN-550 automated body fluid mode and conventional manual microscopy. WBC, RBC, PMN, MN, and HF-cell parameters were evaluated.

Demographic characteristics: Of the 100 CSF samples, 60 (60%) were from male patients and 40 (40%) from female patients, giving a male-to-female ratio of 1.5:1. In the 100 pleural fluid samples, 85 (85%) were from male patients and 15 (15%) from female patients, giving a male-to-female ratio of 5.67:1. The age distribution differed between the groups. In CSF, 56 (56%) samples were from the 1 day to 10 years age group and 25 (25%) were from 31-40 years. In pleural fluid, 53 (53%) samples were from 31-40 years and 17 (17%) from 21-30 years. Detailed age and sex distributions are shown in [Table 1 and 2] as n(%) values.

Table 1: Gender-Based Distribution of Body Fluids Among Patients

Body fluid	Male, n (%)	Female, n (%)	Total, n (%)
CSF	60 (60%)	40 (40%)	100 (100%)
Pleural fluid	85 (85%)	15 (15%)	100 (100%)

Abbreviations: CSF:cerebrospinal fluid.

Table 2: Age-wise distribution of pleural fluid and CSF samples

Age groups (years)	Pleural fluid n (%)	CSF n (%)
1 day–10	4 (4%)	56 (56%)
11–20	5 (5%)	0 (0%)
21–30	17 (17%)	7 (7%)
31–40	53 (53%)	25 (25%)
41–50	3 (3%)	4 (4%)
51–60	9 (9%)	4 (4%)
61–70	6 (6%)	0 (0%)
71–80	2 (2%)	1 (1%)
>81	1 (1%)	3 (3%)
Total	100 (100%)	100 (100%)

Abbreviations: CSF, cerebrospinal fluid; n, number of samples.

Clinical distribution of study samples: According to the available clinical diagnoses, specimens were grouped into inflammatory conditions, malignancy, and other conditions. Overall, inflammatory conditions accounted for 104 (52%) of the 200 samples, other conditions for 92 (46%), and malignancy for four (2%). Among CSF samples, 41 (41%) were associated with inflammatory conditions, one (1%) with malignancy, and 58 (58%) with other conditions. Among pleural fluid samples, 63 (63%)

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were associated with inflammatory conditions, three (3%) with malignancy, and 34 (34%) with other conditions. The clinical distribution is presented in [Table 3] using n(%) values.

Table 3: Distribution of Disease Conditions Among Study Participants With CSF and Pleural Fluid

Sample	Malignancy, n (%)	Inflammation, n (%)	Others, n (%)
CSF (n=100)	1 (1%)	41 (41%)	58 (58%)
Pleural fluid (n=100)	3 (3%)	63 (63%)	34 (34%)
Total (n=200)	4 (2%)	104 (52%)	92 (46%)

Abbreviations: CSF: cerebrospinal fluid.

Comparison of automated and manual cell counts in pleural fluid: Comparison of the Sysmex XN-550 with manual microscopy showed a strong relationship for pleural fluid WBC counts (r = 0.9776). Mean WBC values were 4667.6 cells/µL by manual microscopy and 4334.3 cells/µL by the automated method. RBC counts showed a very strong correlation (r = 0.9999), with mean values of 9819.4 cells/µL manually and 9817.6 cells/µL by the Sysmex XN-550. PMN percentage also correlated strongly (r = 0.9977), with means of 38.61% and 37.92% by manual and automated analysis, respectively. MN percentage showed r = 0.9941, with mean values of 61.26% and 61.42%. HF-cell percentage had a correlation coefficient of r = 0.8723, with mean values of 0.38% by manual microscopy and 0.81% by the analyzer. The corresponding scatter plots are shown in [Figure 1-2].

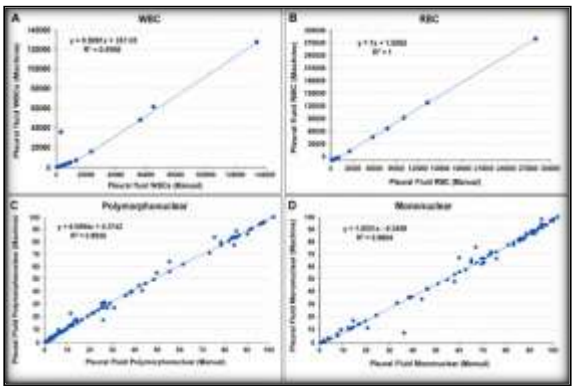


Figure 1: Correlation of Pleural Fluid Cell Counts Between Manual and Automated Methods

Scatter plots demonstrate the correlation between manual and automated analyzer measurements for (A) white blood cell (WBC) count, (B) red blood cell (RBC) count, (C) polymorphonuclear (PMN) cell count, and (D) mononuclear (MN) cell count in 100 pleural fluid samples (n = 100). Manual cell counts are plotted on the x-axis and automated analyzer measurements are plotted on the y-axis. Dotted lines represent the linear regression lines. The corresponding regression equations and coefficients of determination (R^2) are shown in each panel. (A) The regression equation was y = 0.9991x + 337.03, with R^2 = 0.9558. (B) The regression equation was y = 1.00x+ 1.9262, with R^2 = 1.00. (C) The regression equation was y = 0.9994x + 0.3742, with R^2 = 0.9956. (D) The regression equation was y = 0.9673x + 1.5528, with R^2 = 0.9905.

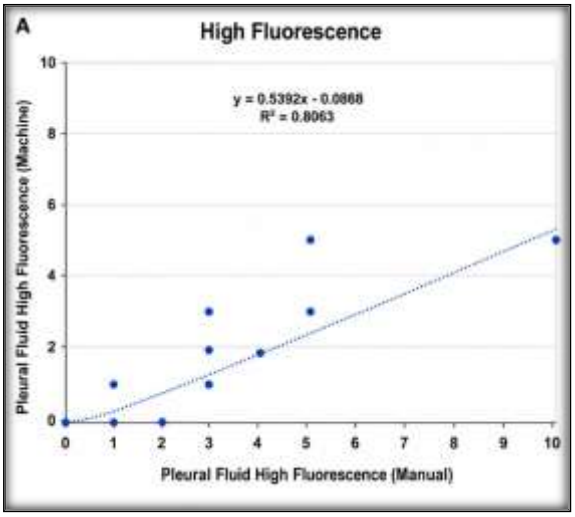


Figure 2: Correlation Between Manual and Automated HF Counts in Pleural Fluid

Scatter plot showing the correlation between manual and automated high-fluorescence cell (HF) counts in pleural fluid samples. The x-axis represents the manual HF count, and the y-axis represents the automated HF count. Abbreviation: HF: high-fluorescence cells.

Comparison of automated and manual cell counts in CSF: For CSF WBC counts, the Sysmex XN-550 showed a very strong relationship with manual microscopy (r= 0.9998). Mean WBC values were 810.98 cells/µL by manual microscopy and 815.85 cells/µL by automated analysis. RBC counts also showed excellent correlation (r = 0.9999), with mean values of 1363.3 cells/µL manually and 1359.5 cells/µL using the Sysmex XN-550. PMN percentages correlated strongly (r = 0.9940), with means of 36.32% and 35.18% for manual and automated methods. MN percentages showed r = 0.9446, with mean values of 63.31% and 64.69%, respectively. HF-cell percentage showed poor correlation (r = −0.0475), with mean values of 1.00% manually and 0.43% by the analyzer. The relevant scatter plots are presented in [Figure 3].

Scatter plots showing the agreement between automated analyzer measurements and manual counting of cerebrospinal fluid (CSF) cells. (a) Total white blood cell (WBC) count, (b) polymorphonuclear (PMN) cell count, (c) mononuclear cell count, and (d) red blood cell (RBC) count. Manual counts are plotted on the x-axis and automated analyzer counts on the y-axis. Blue dots represent individual CSF samples, and the dotted line

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represents the linear regression line. The regression equation and coefficient of determination (R^2) are shown for each parameter. The high R^2 values indicate excellent correlation between automated and manual measurements.

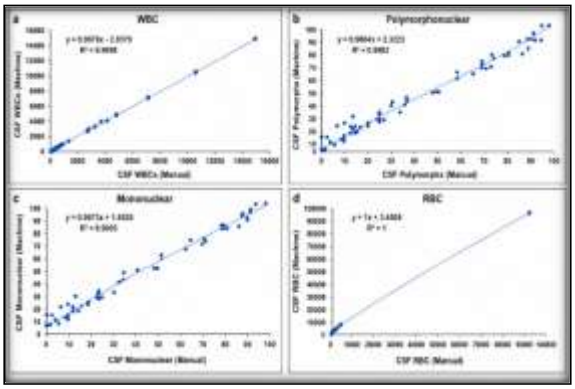


Figure 3: Comparison of CSF Cell Counts Between Automated Analyzer and Manual Counting Method

Comparison of cell count parameters between the two methods: Correlation analysis showed close correspondence between the automated and manual methods for most measured parameters. In CSF, the highest correlations were seen for RBC (r = 0.9999) and WBC (r = 0.9998), followed by PMN (r = 0.9940) and MN (r = 0.9446). HF cells showed poor correlation (r =−0.0475).

For pleural fluid, RBC had the highest correlation (r = 0.9999), followed by PMN (r = 0.9977), MN (r = 0.9941), WBC (r = 0.9776), and HF cells (r = 0.8723). Overall, these results indicate that Sysmex XN-550 measurements were closely related to manual microscopy for routine WBC, RBC, PMN, and MN assessment in both fluid types.

Evaluation of CSF with abnormal cellular populations: One CSF specimen from a patient with acute lymphoblastic leukemia was additionally examined to evaluate analyzer performance in the presence of abnormal cells. Although the automated WBC count correlated strongly with the manual result, the automated differential could not reliably separate abnormal lymphoid cells from the other mononuclear cells. Comparison of the automated MN population with the corresponding manual mononuclear population, including the abnormal cellular component, showed a strong correlation (r = 0.994; slope = 0.96). This supports the need for microscopic examination to identify and characterize abnormal or malignant cells, as illustrated in [Figure 4].

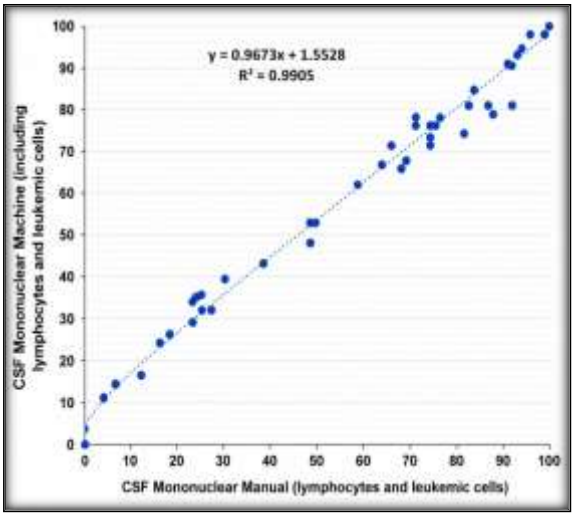


Figure 4: Comparison of CSF Mononuclear High-Fluorescence Cell Counts by Microscopy and Automated Analysis

Comparison of mononuclear high-fluorescence cell counts in cerebrospinal fluid (CSF) samples obtained by microscopy and automated analysis. Abbreviations: CSF: cerebrospinal fluid.

Evaluation of pleural fluid samples with atypical cells: Five pleural fluid specimens showed atypical cells on wet-mount or Neubauer chamber examination and were subsequently evaluated cytologically. Two cases were confirmed as malignant, one was considered suspicious for malignancy, and two showed atypical cells without confirmation of malignancy, as shown in Table 4. These observations emphasize that automated counting cannot substitute for microscopy when morphological identification of atypical or malignant cells is required.

Table 4: Comparison Between Wet-Mount and Cytological Reports

Case	Wet-mount report	Cytological report
First	Atypical cells	Malignancy
Second	Atypical cells	Malignancy
Third	Atypical cells	Suspicious of malignancy
Fourth	Atypical cells	Atypical cells
Fifth	Atypical cells	Atypical cells

DISCUSSION

94) Accurate and prompt body fluid cell analysis is important in the diagnosis and management of infectious, inflammatory, hemorrhagic, and malignant disorders. In this study, the Sysmex XN-550 automated body-fluid mode was compared with conventional manual microscopic counting in 200 specimens, consisting of 100 CSF and 100 pleural fluid samples. Most evaluated parameters showed strong correlations between the two methods.

For CSF, WBC, RBC, PMN, and MN measurements showed strong correlations, with Pearson coefficients of 0.9998, 0.9999, 0.9940, and 0.9446, respectively. The corresponding coefficients in pleural fluid were

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0.9776, 0.9999, 0.9977, and 0.9941. These results indicate that the Sysmex XN-550 produced measurements closely associated with manual microscopy for routine cellular enumeration in CSF and pleural fluid.

CSF WBC count

The CSF WBC correlation between automated and manual measurements was extremely strong (r = 0.9998). This agrees with earlier reports describing good agreement between automated body fluid analyzers and conventional microscopic techniques.[3,6-8] Manual CSF counting with a Neubauer chamber remains an important reference method, although pipetting, chamber loading, cell distribution, cell lysis, and observer variation can influence results. The very strong correlation found here suggests that the Sysmex XN-550 can be used reliably for routine CSF WBC enumeration. CSF WBC counts were grouped into <500 cells/µL, 500-1000 cells/µL, and >1000 cells/µL. Most specimens were in the <500 cells/µL category, and good correlation was seen across the assessed ranges. Because CSF normally contains few WBCs, accurate enumeration is important when infection, inflammation, or malignant infiltration is suspected.

CSF differential count

Automated and manual PMN percentages showed a very strong correlation (r = 0.9940), while the MN correlation was also strong (r = 0.9446) but somewhat lower. These findings are broadly similar to previous studies of automated body-fluid analysis. Fleming et al. reported excellent agreement for CSF WBC and differential counts, and other investigators have also found strong relationships for WBC, PMN, and MN populations.[3,6,9] The lower MN correlation may be related to morphological variation, reactive cells, degeneration, or limitations of automated classification.

RBC count

CSF RBC counts showed an almost perfect correlation between the two methods (r = 0.9999), indicating excellent association. Reliable RBC measurement is useful when assessing hemorrhage and when distinguishing true blood in the CSF from contamination due to a traumatic lumbar puncture.

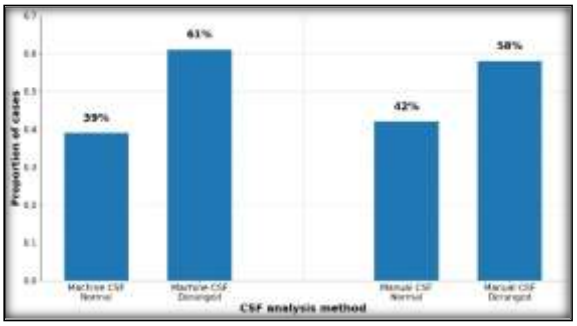


Figure 5: Comparison of Normal and Deranged WBC Counts by Automated Analysis and Microscopy

CSF HF cells

Unlike the other parameters, CSF HF-cell measurements showed poor correlation between automated and manual methods (r = −0.0475). This is relevant because HF signals may occur with abnormal or atypical cell populations. Automated analyzers classify cells according to physical and optical properties and may not consistently distinguish malignant cells from reactive populations [Figure 5].

Comparison of normal and deranged white blood cell (WBC) counts obtained by automated analysis and microscopy. Abbreviation: WBC: white blood cells.

Specimens with abnormal scattergram patterns, analyzer flags, high HF signals, or clinical concern for malignancy should therefore undergo microscopic review. In this study, the CSF specimen from a patient with acute lymphoblastic leukemia demonstrated the importance of microscopy. Although the automated system provided a reliable total WBC count, identification of abnormal lymphoid cells required microscopic assessment. Thus, the analyzer is useful for routine screening and enumeration but cannot replace manual examination when abnormal cells are suspected.

Pleural fluid WBC count

Pleural fluid WBC counts showed a strong correlation between automated and manual methods (r = 0.9776). Pleural fluid WBC measurement can assist in evaluating infectious and inflammatory processes. A higher PMN proportion may accompany acute bacterial infection, whereas lymphocyte-predominant effusions can occur with tuberculosis, malignancy, viral infection, rheumatoid pleuritis, and other conditions. The strong correlation in this study supports the routine use of the Sysmex XN-550 for pleural fluid WBC enumeration.

Pleural fluid differential count

Pleural fluid PMN percentages showed a very strong correlation (r = 0.9977), while MN percentages also correlated strongly (r = 0.9941). These results indicate that the analyzer can provide differential results that are highly consistent with manual microscopy for routine PMN and MN populations. Similar findings have been reported in earlier evaluations of automated body-fluid analysis.[9]

Pleural fluid RBC count

Pleural fluid RBC counts showed an almost perfect correlation between automated and manual methods (r = 0.9999). RBC enumeration is clinically relevant in hemorrhagic pleural effusions, which may occur with trauma, malignancy, pulmonary embolism, pulmonary infarction, tuberculosis, and other disorders. The observed correlation indicates that automated RBC counting with the Sysmex XN-550 is highly comparable to manual counting.

Pleural fluid HF cells

The correlation for HF-cell percentages in pleural fluid was 0.8723. Although this was lower than the correlations for WBC, RBC, PMN, and MN measurements, it remained a positive association. HF populations require careful interpretation because

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pleural fluid can contain macrophages, mesothelial cells, reactive cells, and malignant cells. These populations may affect automated classification and produce abnormal scattergram patterns. Microscopic examination is therefore still required when atypical or malignant cells are suspected. In this study, several pleural fluid samples showed atypical cells on wet-mount or microscopic examination, and subsequent cytology confirmed malignancy in some cases while others were suspicious or atypical. These findings support microscopic review of selected specimens.

Automated versus manual methods

Manual microscopy has traditionally served as the reference approach for body fluid cell counting. It nevertheless has limitations, including pipetting and chamber-loading errors, dilution errors, cell loss, cellular degeneration, and variation between observers. Automated analysis can reduce some of these sources of variation and may shorten laboratory turnaround time. The present study showed particularly strong correlations for WBC and RBC measurements and for PMN and MN differential percentages. However, correlation alone does not establish complete agreement between methods. A strong correlation means that measurements tend to change together; it does not prove that the methods produce identical values or are free of systematic bias. Automated results should therefore be considered together with clinical findings, analyzer flags, scattergrams, and microscopy.

Abnormal and malignant cells

A key limitation of automated body fluid analysis is the difficulty in reliably recognizing malignant cells. Body fluids may contain malignant cells, reactive mesothelial cells, macrophages, immature hematopoietic cells, blasts, cellular debris, and other non-hematopoietic populations. Some of these can overlap with normal WBC populations in automated classification systems. Manual microscopic differential assessment remains essential when malignancy or hematological malignancy is suspected, when scattergrams are abnormal, analyzer flags are present, HF-cell signals are high, WBC counts are unexpectedly elevated, clinical findings are unusual, or atypical morphology is observed. This is especially important in CSF from patients with leukemia or lymphoma, in whom even a small abnormal cell population can be clinically significant.

Comparison with previous studies

The correlations observed in this study were broadly comparable with, and in some parameters higher than, those reported in earlier investigations, particularly for WBC and RBC measurements. Previous studies similarly support the use of automated body-fluid analyzers for routine cell counting while retaining microscopic examination for selected specimens, as summarized in [Table 5].

Table 5: Comparison of Correlation Results for CSF With Previous Studies

Study	WBC (r_s)	RBC (r_s)	PMN (r_s)	MN (r_s)	HF (r_s)
Present study	0.99	0.999	0.99	0.94	−0.0475
Paris et al,[9]	0.959	0.95	0.997	0.979	Nil
Fleming et al,[3]	0.99	0.98	1	0.98	Nil
Takemura et al,[12]	0.743	Nil	0.743	0.819	Nil

Abbreviations: CSF, cerebrospinal fluid; HF, high-fluorescence cells; MN, mononuclear cells; PMN, polymorphonuclear cells; RBC, red blood cells; WBC, white blood cells; r_s, correlation coefficient. Nil indicates that the corresponding parameter was not reported in the cited study. Reference numbers correspond to the manuscript reference list.

Overall, the present findings are broadly consistent with previous investigations evaluating automated body fluid analysis, as summarized in [Table 6].

Table 6: Comparison of Correlation Results for Pleural Fluid With Previous Studies

Study	WBC (r_s)	RBC (r_s)	PMN (r_s)	MN (r_s)	HF (r_s)
Present study	0.97	0.999	0.99	0.87	Nil
Paris et al. [9]	0.959	0.95	0.997	0.979	Nil
Takemura et al. [12]	0.99	Nil	0.973	0.939	Nil
Walker et al. [13]	0.99	Nil	Nil	Nil	Nil
Savcı et al. [14]	0.949	Nil	Nil	Nil	Nil

Abbreviations: HF, high-fluorescence cells; MN, mononuclear cells; PMN, polymorphonuclear cells; RBC, red blood cells; WBC, white blood cells; rs correlation coefficient. Nil indicates that the corresponding parameter was not reported in the cited study. Reference numbers correspond to the manuscript reference list.

CONCLUSION

The Sysmex XN-550 body-fluid mode showed strong correlations with conventional manual microscopy for WBC and RBC counts and for PMN and MN differential measurements in both CSF and pleural fluid. These findings support automated analysis as a useful first-line approach for routine body fluid counting and suggest that it may reduce manual workload and turnaround time. However, automated testing should not entirely replace microscopy. Manual review remains important when malignant, atypical, immature, or otherwise abnormal cells are suspected, when analyzer flags or abnormal scattergrams are present, and when HF-cell results are unusual. The Sysmex XN-550 can therefore be

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regarded as a useful routine and screening tool used alongside manual microscopy as a complementary reference method.

Automated body-fluid analysis may be influenced by interfering material such as cellular debris, bacteria, fungi, proteinaceous material, lipids, crystals, incompletely lysed RBCs, and non-hematopoietic cells. Such material can affect automated classification and may lead to inaccurate counts. Macrophages and mesothelial cells may also influence total nucleated-cell measurements and scattergram interpretation. Analyzer flags and scattergrams should therefore be reviewed carefully, particularly for serous fluids. The study also had several limitations: it was performed at a single tertiary-care institution; the number of specimens with confirmed malignant cells was small; correlation analysis alone cannot demonstrate analytical equivalence or agreement; and HF-cell assessment showed substantial differences between automated and manual methods, particularly in CSF. Future multicenter studies with larger populations, Bland-Altman or other method-comparison statistics, and more malignant or atypical specimens would provide additional information on clinical utility.

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