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Baseline Complete Blood Count and Cell Population Data as Prognostic Markers for In-Hospital Mortality among COVID-19 Patients admitted at the Philippine General Hospital from March 2020 to January 2022

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ABSTRACT

Introduction. Complete blood count (CBC) and cell population data (CPD) are hematologic parameters used in several clinical scenarios including infection and neoplastic processes. In the setting of COVID-19 infection, there is relative paucity of data in their use as possible prognostic markers.

Objective. We aim to evaluate the utility of the baseline CBC and CPD as prognostic markers for in-hospital mortality among COVID-19 patients admitted in Philippine General Hospital from March 2020 to January 2022.

Methodology. This is a case-control study. Expired patients served as cases, and recovered patients served as controls. Data from eligible patients including age, sex, admitting COVID diagnosis with severity, final disposition, baseline CBC and CPD results were collected from the hospital medical records and hematology section of the Department of Laboratories. Statistical analyses were done to determine the prognostic value of these parameters for in-hospital mortality.

Results. Among the different CBC and CPD parameters, the study shows total white blood cell (WBC) count, absolute neutrophil count (ANC), absolute eosinophil count (AEC), and neutrophil-lymphocyte ratio (NLR) were statistically significant predictors for in-hospital mortality. For total WBC count, at a cut off 9.9 x 10^9/L, the sensitivity and specificity is 70.9% and 66.2%, respectively. For ANC, at a cut off of 7.3 x 10^9/L, the specificity is 76.4% and the specificity is 68.2%. At a cut off of 7.62, the NLR shows a sensitivity of 76.4% and specificity of 70.1%. For AEC, at a cut off of 0.006 x 10^9/L, the sensitivity is 53.3% and the specificity is 87.3%. AEC predicts towards the direction of survival rather than to the direction of in-hospital mortality.

Conclusion. The total WBC count, ANC, and NLR were statistically significant predictors for in-hospital mortality, while AEC predicts towards the direction of survival. The sensitivities and specificities of the cut off for these parameters were less than ideal. Correlation with clinical and other laboratory parameters is still recommended. For future studies, the authors recommend monitoring CBC and CPD parameters at different time points during the patients' hospital course.

Key words: COVID-19, hematology, blood cell count, complete blood count, prognosis, cell population data

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INTRODUCTION

Coronavirus Disease 2019 (COVID-19) is an ongoing pandemic caused by the Severe Acute Respiratory Syndrome Coronavirus (SARS-CoV-2). As of January 2022, the World Health Organization (WHO) has recorded more than 300 million cases globally with more than 5.5 million deaths. The Philippines has recorded more than 3 million cases with more than 52,000 deaths in the same period.[1]

The clinical spectrum of COVID-19 ranges from asymptomatic illness to severe, life-threatening disease. While the ultimate outcome of patients depends on various factors, identification of prognostic parameters to determine which patients could progress to critical disease may aid in early intervention measures.

Complete blood count (CBC) is an inexpensive and widely available test in most hospitals and diagnostic facilities. Several hematologic changes have been reported in COVID-19, and most changes are associated with the white blood cell component. 20-40% of patients present with leukopenia, while 3-24% have leukocytosis.[2] Strong association was found between lymphopenia and severe COVID-19.[3] Neutrophilia has also been reported in patients with severe manifestations.

Other studies show mild thrombocytopenia in 5-21% of COVID-19 patients.[2] However, studies also show that significant thrombocytopenia is associated with higher mortality risk.[4] Hemoglobin changes in COVID-19 infection are variable and conflicting.[5] Reduced levels in a meta-analysis have been documented in severe cases.[6]

A combination of these parameters has also been studied to evaluate disease severity in COVID-19 patients. An elevated neutrophil to lymphocyte ratio (NLR) was a marker for increased mortality and severity.[7] Platelet to lymphocyte ratio (PLR) is significantly increased in critical patients as compared to those with lesser severity of infection. Conversely, a decreased lymphocyte to monocyte ratio (LMR) is observed among severe cases.[8,9]

The postulated mechanism for lymphopenia is direct invasion by the virus into lymphocytes through ACE2 receptors.[10] Lactic acidosis, a common finding in COVID-19 infection, may also result in decreased lymphocyte proliferation.[11] Neutrophilia may be virally induced, or secondary to a concomitant bacterial infection.[12] Secondary hemophagocytic lymphohistiocytosis from COVID-19 causes excessive proliferation and activation of macrophages, and in turn results in a cytokine storm. The surge in inflammatory cytokines damages hematopoietic progenitors and also reduces platelet production.[13]

Some hematology analyzers can generate Cell Population Data (CPD) values through Volume, Conductivity, and Scatter (VCS) Technology. This technology enables assessment of cellular volume, cell surface structure, cytoplasmic chemical composition, and nuclear topography. Changes among these parameters reflect the morphological adaptation of cells to various triggers and changes in the internal milieu.[14]

The Unicel DxH 900 (Beckman Coulter, Miami, FL, USA), the analyzer used in Philippine General Hospital (PGH), can generate CPD as a research feature. Values for volume, conductivity, axial light loss (AL2), low-angle light scatter (LALS), median-angle light scatter (MALS), lower median angle light scatter (LMALS), and upper median angle light scatter (UMALS) can be generated for each CBC run.

Studies have utilized these parameters in the setting of sepsis[15] and differentiation between viral and bacterial infections in children.[16] Few studies to date have utilized these parameters in the COVID-19 setting. From a diagnostic perspective, monocyte volume served as the best discriminator between COVID-19 and non-COVID-19 patients, with a sensitivity of 89.7% and specificity of 60.5%.[17]

In terms of prognosis, a study showed that neutrophils have increased volume and decreased conductivity, while lymphocytes show increased conductivity, among fatal COVID cases.[18]

In this study, we describe our findings on baseline CBC and CPD as prognostic markers for in-hospital mortality among COVID-19 patients admitted in a tertiary government hospital.

METHODOLOGY

This study was submitted to the University of the Philippines – Manila Research Ethics Board for approval prior to implementation.

Research design

This is a case-control study investigating the prognostic utility of baseline CBC and CPD findings in predicting in-hospital mortality among COVID-19 patients admitted in PGH from March 2020 to January 2022. Expired patients served as cases, and recovered patients served as controls.

Sampling

Purposive sampling was done for this study by employing an inclusion and exclusion criteria. All patients admitted in PGH from March 2020 to January 2022 that fulfill the inclusion and exclusion criteria were included in the study.

Inclusion and exclusion

The study included patients more than 18 years old, admitted with a primary clinical suspicion of COVID-19 (i.e., symptoms compatible with COVID-19), confirmed by Reverse Transcriptase-Polymerase Chain Reaction (RT-PCR) done in PGH; with a baseline CBC test with corresponding CPD parameters done in PGH using the Unicel DxH 900; and with a final disposition as to "Discharged" or "Expired" based on the Hospital Medical Records.

Patients with incidental diagnoses of COVID-19 after admission for another disease, or those with concomitant acute inflammatory conditions on admission (i.e., acute infection) not consistent with COVID-19 infection, were excluded.

Data collection procedures

A list of patients admitted in the PGH COVID-19 ward from March 2020 to January 2022 was requested from the Medical Records Division and was screened according to the inclusion and exclusion criteria. Eligible patients were assigned unique code numbers. The age, sex, admitting COVID diagnosis (including disease severity), and final disposition ("Discharged"/ "Expired"), and baseline CBC results of the patients were collected. The corresponding CPD values for the baseline CBC were requested from the Hematology Section of the Department of Laboratories. The CPD values include the mean and standard deviation of Neutrophil, Lymphocyte, Monocyte, Eosinophil and Early Granulated Cell – AL2, LALS, UMALS, LMALS and MALS.

RESULTS

The study population included 235 patients – 168 of which were survivors while 67 died from the disease. Among the survivors, 83 were male and 85 were female, with a median age of 56. Severity of disease on admission among this group are as follows: moderate (109), severe (49), and critical (3). Among the in-house mortality group, 43 were male and 24 were female, with a median age of 63. Severity of disease on admission among this group are as follows: moderate (31), severe (29), and critical (3). The difference in clinicodemographic characteristics of the participants is not homogenous between those who survived and those who died in-hospital by Mann-Whitney U test. Propensity score matching in a 2:1 ratio between in-hospital mortalities and survivors was done using a logit model for in-hospital mortality with the following covariates: age, sex, and COVID-19 disease severity. Caliper matching without replacement was used, with an a priori caliper width set at 0.20 times the SD of the propensity score. Only 162 participants were then included in the data analysis. We can note that the propensity score matching has addressed the heterogeneity of the included participants in the case and control groups (Table 1).

A point-biserial correlation analysis was done between the CBC and CPD parameters and severity of COVID-19 disease on admission. Because of the low representation of the Critical group, it has been grouped together with Severe for this analysis. The following parameters showed significantly weak correlation with disease severity on admission: absolute lymphocyte count, r=-0.25, $p<0.01$; monocyte LMALS, r=0.25, $p=0.001$; monocyte MALS, r=0.22, $p=0.004$; and PLR, r=0.38, $p<0.001$. The absolute lymphocyte count has an inverse relationship with disease severity on admission while the other three parameters have a direct relationship with disease severity. The rest of the blood parameters have negligible or without evidence of correlation with COVID-19 disease severity on admission (Table 2).

The following blood parameters show significantly higher median among in-hospital mortality than among survivors: total WBC count $p<0.001$, absolute neutrophil count (ANC) $p<0.001$, neutrophil volume $p<0.001$, lymphocyte MALS $p=0.003$, lymphocyte UMALS $p=0.012$, monocyte LALS $p=0.043$, and NLR $p<0.001$. In contrast, the following blood parameters show significantly lower median among in-hospital mortality than among survivors: neutrophil conductivity $p=0.009$, neutrophil LMALS $p=0.019$, absolute lymphocyte count (ALC) $p=0.004$, lymphocyte LALS $p=0.033$, lymphocyte ALL $p=0.002$, absolute eosinophil count (AEC) $p<0.001$, eosinophil volume $p=0.002$, early granulocyte conductivity $p=0.017$, early granulocyte MALS $p=0.053$, platelet count $p=0.003$, and LMR $p=0.005$. The rest of the blood parameters have no significant difference in median values (Table 3).

The ROC curve analysis showed that the AUC of the following blood parameters are good predictors of mortality: total WBC count (0.7, 95% CI), ANC (0.7, 95% CI), AEC (0.7, 95% CI), and NLR (0.7, 95% CI). The rest of the blood parameters are poor predictors mortality (95%CI crossing 0.6000) or have no evidence of predicting ability (95%CI crossing 0.5000). Parameters with AUC significantly higher than 0.6000 proceed to cut off determination (Table 4).

For total WBC count, at a cut off 9.9 x 10^9/L, the sensitivity and specificity is 70.9% and 66.2%, respectively. For ANC, at a cut off of 7.3 x 10^9/L the specificity is 76.4% and the specificity is 68.2%. At a cut off of 7.62, the NLR shows a sensitivity of 76.4% and specificity of 70.1%. For AEC, at a cut off of 0.006 x 10^9/L, the sensitivity is 53.3% and the specificity is 87.3%. The latter parameter, however, predicts towards the direction of survival rather than to the direction of in-hospital mortality (Table 5).

DISCUSSION

The in-hospital mortality group in the study shows significant higher WBC counts with concomitant higher ANC. While these parameters did not show correlation with disease severity on admission, the study suggests they are possible markers for poor outcome. Neutrophilia has been historically documented in sepsis and bacteremic states as an early manifestation of immune cell response to severe infection. In the setting of COVID-19 infection, neutrophilia is correlated with the hyperinflammatory state and cytokine storm associated with the disease. The neutrophilia is documented not only in the bloodstream but also in lung tissue where they contribute to further tissue damage.[19]

The NLR is also shown as a predictor for mortality in the study. This reflects not only the increase in neutrophils, but also a decrease in ALC. The median ALC has been shown in this study to be significantly lower among the

Table 1. Clinicodemographic profile of all the participants included in the study, and the propensity score-matched participants that were included in the data analysis

Clinicodemographic profile	All included subjects			1:2 Propensity score-matched		
	In-hospital mortality n = 67	Survivor n = 168	p-value	In-hospital mortality n = 55	Survivor n = 107	p-value
Age, years, median (IQR)	56 (25)	63 (22)	<0.001	61 (20)	60 (15)	0.657
Sex, count (%)			0.040			0.805
Male	83 (49.40%)	43 (64.18%)		34 (61.82%)	64 (59.81%)	
Female	85 (50.60%)	24 (35.82%)		21 (38.18%)	43 (40.19%)	
Disease severity on admission, count (%)			0.024			0.940
Moderate	109 (67.70%)	31 (49.21%)		30 (54.55%)	61 (57.01%)	
Severe	49 (30.43%)	29 (46.03%)		24 (43.64%)	44 (41.125)	
Critical	3 (1.86%)	3 (4.76%)		1 (1.82%)	2 (1.87%)	

Table 2. Point-biserial correlation analysis between CBC and CPD parameters with disease severity

Blood cell parameters	Correlation coefficient	90% CI	p-value
Total WBC count	-0.0362	-0.1651, 0.0940	0.648
Neutrophil			
Absolute count	0.0081	-0.1217, 0.1377	0.918
Volume	-0.1893	-0.3114, -0.0611	0.016
Conductivity	0.0454	-0.0848, 0.1741	0.566
Median-angle light scatter	0.0055	-0.1243, 0.1351	0.944
Upper median-angle light scatter	-0.0123	-0.1418, 0.1176	0.877
Lower median-angle light scatter	0.0305	-0.0996, 0.1595	0.700
Low-angle light scatter	-0.0464	-0.1751, 0.0838	0.557
Axial light loss	0.0773	-0.0530, 0.2049	0.328
Lymphocyte			
Absolute count	-0.2547	-0.3721, -0.1292	0.001
Volume	-0.0335	-0.1625, 0.0966	0.672
Conductivity	0.1258	-0.0040, 0.2524	0.111
Median-angle light scatter	0.1048	-0.0252, 0.2314	0.184
Upper median-angle light scatter	0.1455	0.0161, 0.2701	0.065
Lower median-angle light scatter	0.1470	0.0177, 0.2716	0.062
Low-angle light scatter	-0.0766	-0.2043, 0.0537	0.333
Axial light loss	0.1003	-0.0298, 0.2271	0.204
Monocyte			
Absolute count	-0.1081	-0.2345, 0.0219	0.171
Volume	-0.1085	-0.2349, 0.0215	0.169
Conductivity	0.0886	-0.0416, 0.2158	0.262
Median-angle light scatter	0.2241	0.0972, 0.3438	0.004
Upper median-angle light scatter	0.1062	-0.0238, 0.2327	0.179
Lower median-angle light scatter	0.2553	0.1299, 0.3737	0.001
Low-angle light scatter	0.1831	0.0547, 0.3055	0.020
Axial light loss	0.1670	0.0381, 0.2904	0.034
Eosinophil			
Absolute count	-0.0620	-0.1902, 0.0683	0.433
Volume	-0.0910	-0.2267, 0.0483	0.282
Conductivity	0.0814	-0.0579, 0.2176	0.336
Median-angle light scatter	0.0575	-0.0817, 0.1946	0.497
Upper median-angle light scatter	0.1020	-0.0372, 0.2372	0.227
Lower median-angle light scatter	0.0520	-0.0872, 0.1893	0.539
Low-angle light scatter	-0.0128	-0.01512, 0.1260	0.879
Axial light loss	0.0526	-0.0867, 0.1898	0.535
Early granulocyte			
Absolute count	-	-	-
Volume	-0.1752	-0.3078, -0.0360	0.039
Conductivity	0.0253	-0.1153, 0.1648	0.768
Median-angle light scatter	0.0468	-0.0939, 0.1857	0.584
Upper median-angle light scatter	0.0069	-0.1334, 0.1469	0.936
Lower median-angle light scatter	0.0580	-0.0928, 0.1965	0.498
Low-angle light scatter	0.0187	-0.1217, 0.1584	0.827
Axial light loss	0.1066	-0.0340, 0.2431	0.212
Platelet count	0.1345	0.0049, 0.2597	0.088
Neutropil:lymphocyte ratio	0.1691	0.0398, 0.2927	0.032
Platelet:lymphocyte ratio	0.3776	0.2603, 0.4839	<0.001
Lymphocyte:monocyte ratio	-0.1260	-0.2516, 0.0038	0.110

in-hospital mortality group compared to the survivor group. Together with the ANC, lymphopenia also suggests disease progression and poor outcome. The cause of lymphopenia is hypothesized to be due to viral-induced apoptosis.[20] Another theory is that viral attachment induces ACE-2 receptor expression on the lymphocyte's surface which increases the probability of being a target of the virus.[21] Both these parameters result in an increased NLR which has shown predictive ability for mortality.

The role of eosinophils in COVID-19 disease is largely unknown. According to a study, the findings of eosinopenia, together with neutrophilia and lymphopenia, is consistent among COVID-19 patients.[22] Eosinopenia is also uncommonly found in other conventional viral infections. Tan et al noted that eosinophils were inversely related to the severity of the disease. Furthermore, eosinophil counts returned to normal levels upon discharge.[23] The results from this study showed that AEC is associated with disease survival.

CPD parameters with higher median among the in-hospital mortality group compared to the survivors in the initial analysis include total WBC count, ANC, neutrophil volume, lymphocyte MALS, lymphocyte UMALS, monocyte LALS, and NLR. These changes are brought about by the activation and alterations in internal complexity of these cells in response to a trigger (i.e., infection). However, none of these parameters were statistically significant on further analysis. Because of the novelty of these parameters, only a few cohorts have studied its application in the setting of COVID disease. One study compared

Table 3. Initial screening of possible admission CBC and CPD parameters as predictors of in-hospital mortality among admitted COVID-19 patients

Blood cell parameters	In-hospital mortality n = 55, Median (IQR)	Survivor n = 107, Median (IQR)	p-value
Total WBC count	11.4 (7)	7.5 (5.8)	<0.001
Neutrophil			
Absolute count	9.9 (7.33)	5.13 (5.15)	<0.001
Volume	148 (13)	142 (8)	<0.001
Conductivity	144 (7)	145 (6)	0.009
Median-angle light scatter	135 (9)	138 (9)	0.096
Upper median-angle light scatter	136 (7)	137 (5)	0.742
Lower median-angle light scatter	127 (12)	132 (13)	0.019
Low-angle light scatter	153 (22)	156 (19)	0.504
Axial light loss	133 (11)	135 (22)	0.294
Lymphocyte			
Absolute count	0.8 (1.1)	1.14 (0.8)	0.004
Volume	88 (7)	88 (8)	0.819
Conductivity	116 (4)	115 (5)	0.292
Median-angle light scatter	74 (9)	71 (7)	0.006
Upper median-angle light scatter	75 (14)	71 (11)	0.012
Lower median-angle light scatter	65 (6)	63 (4)	0.072
Low-angle light scatter	34 (4)	35 (4)	0.033
Axial light loss	58 (10)	63 (33)	0.002
Monocyte			
Absolute count	0.68 (0.61)	0.69 (0.39)	0.911
Volume	176 (13)	173 (11)	0.051
Conductivity	124 (5)	124 (5)	0.953
Median-angle light scatter	90 (7)	90 (5)	0.271
Upper median-angle light scatter	99 (9)	98 (5)	0.331
Lower median-angle light scatter	77 (9)	76 (5)	0.147
Low-angle light scatter	87 (16)	79 (19)	0.008
Axial light loss	115 (10)	116 (43)	0.216
Eosinophil			
Absolute count	0 (0)	0.04 (0.16)	<0.001
Volume	147 (14)	153 (16)	0.002
Conductivity	153 (10)	151 (8)	0.053
Median-angle light scatter	195 (15)	198 (13)	0.285
Upper median-angle light scatter	205 (24)	208 (12)	0.066
Lower median-angle light scatter	180 (17)	182 (13)	0.718
Low-angle light scatter	154 (25)	160 (19)	0.101
Axial light loss	122 (24)	123 (12)	0.658
Early granulocyte			
Absolute count	-	-	-
Volume	168 (20)	163.5 (20)	0.092
Conductivity	133 (5)	135 (5)	0.017
Median-angle light scatter	142 (7)	144 (7)	0.053
Upper median-angle light scatter	153 (10)	156 (8)	0.087
Lower median-angle light scatter	127 (10)	128.5 (10)	0.129
Low-angle light scatter	116 (16)	118.5 (22)	0.822
Axial light loss	138 (15)	142 (38)	0.101
Platelet count	212 (182)	282 (194)	0.003
Neutropil:lymphocyte ratio	12.29 (14.61)	4.47 (6.27)	<0.001
Platelet:lymphocyte ratio	255.19 (400.8)	232.46 (244.2)	0.916
Lymphocyte:monocyte ratio	1.25 (1.45)	1.73 (1.13)	0.005

these research parameters among COVID-19 ICU and Non-ICU patients. The study showed that in spite of the striking differences in the morphology of neutrophils, lymphocytes, and monocytes, these research parameters did not show any differences between the two groups.[20] Of note, the latter study used a different analyzer from the one used in this research. One study noted that a subset of their study population with severe and or fatal disease demonstrated increase volume and decreased conductivity of neutrophils, and increased conductivity of lymphocytes.[22] These contradictory results suggest that further studies may still need to be done on the usefulness these research parameters in the setting of COVID.

Important limitations of the study include non-measurement of vaccination status and actual treatment received by the study population. A study by Graña et al showed high-certainty evidence of a reduction in severe or critical COVID-19 cases compared to placebo after vaccination with the following: BNT162b2, mRNA-1273, Ad26.COV2.S, and BBV152. These vaccines are included in the Philippine vaccination drive against COVID-19. Efficacy rates of these vaccines were noted in the range of 76.3% to 98.2% (95% CI).[24] Among hospitalized cases, including non-critical and critical admissions, vaccination has been shown to markedly reduce adverse outcomes including mortalities.[25] Treatment practices may have also shifted as new knowledge on management are being

Table 4. Receiver operating characteristic curve analysis of admission CBC and CPD parameters as predictors of in-hospital mortality among admitted COVID-19 patients

Blood cell parameters	AUC	95% CI
Total WBC count	0.7098	0.6110, 0.8085
Neutrophil		
Absolute count	0.7486	0.6538, 0.8435
Volume	0.6738	0.5657, 0.7819
Conductivity*	0.6480	0.5432, 0.7527
Lower median-angle light scatter*	0.6106	0.5057, 0.7156
Lymphocyte		
Absolute count*	0.5574	0.4399, 0.6750
Median-angle light scatter	0.6540	0.5433, 0.7647
Upper median-angle light scatter	0.6774	0.5665, 0.7883
Low-angle light scatter*	0.5634	0.4553, 0.6715
Axial light loss*	0.6396	0.5350, 0.7443
Monocyte		
Low-angle light scatter	0.6463	0.5461, 0.7466
Eosinophil		
Absolute count*	0.7048	0.6271, 0.7825
Volume*	0.6379	0.5308, 0.7450
Early granulocyte		
Conductivity*	0.6486	0.5408, 0.7563
Platelet count*	0.6352	0.5283, 0.7421
Neutropil:lymphocyte ratio	0.7125	0.6128, 0.8122
Lymphocyte:monocyte ratio*	0.5495	0.4296, 0.6695

*Predicts towards the direction of survival rather than to the direction of in-hospital mortality.

constantly updated,[26] where in triaging of cases and management is based on disease severity on admission. Given the association between vaccination status and disease severity, as well as disease severity on admission and patient management, disease severity on admission served as surrogate marker for these unmeasured factors. The possible confounding effects of disease severity were addressed by propensity score matching, as previously described.

Ultimately, four parameters from this study showed significant results in predicting in-hospital mortality among COVID-19 patients: total WBC count, ANC, AEC, and NLR. At best, the ANC has the highest sensitivity and specificity of 76.4% and 68.2%, respectively, at a cut off of 7.3 x 10^9/L, followed by total WBC count with 70.9% and 66.2%, respectively, at a cut off of 9.9 x 10^9/L. Results from a study using the same analyzer showed an AUC of 0.744 ($p<.001$) with a sensitivity of 69% and specificity of 71% for neutrophil counts at a cut off of 5.6 x 10^9/dL in predicting admission for COVID-19.[22] Another study that compared hematologic parameters between non-severe and severe COVID-19 infected groups, the authors noted that for WBC at a cut off of 7.5, the sensitivity is 65% and the specificity is 53.5%; for Neutrophil count, at a cut off of 4.65, the sensitivity is 75% and the specificity is 60%; lastly, for NLR, at a cut off of 2.98, the sensitivity is 75% and the specificity is 61%.[27]

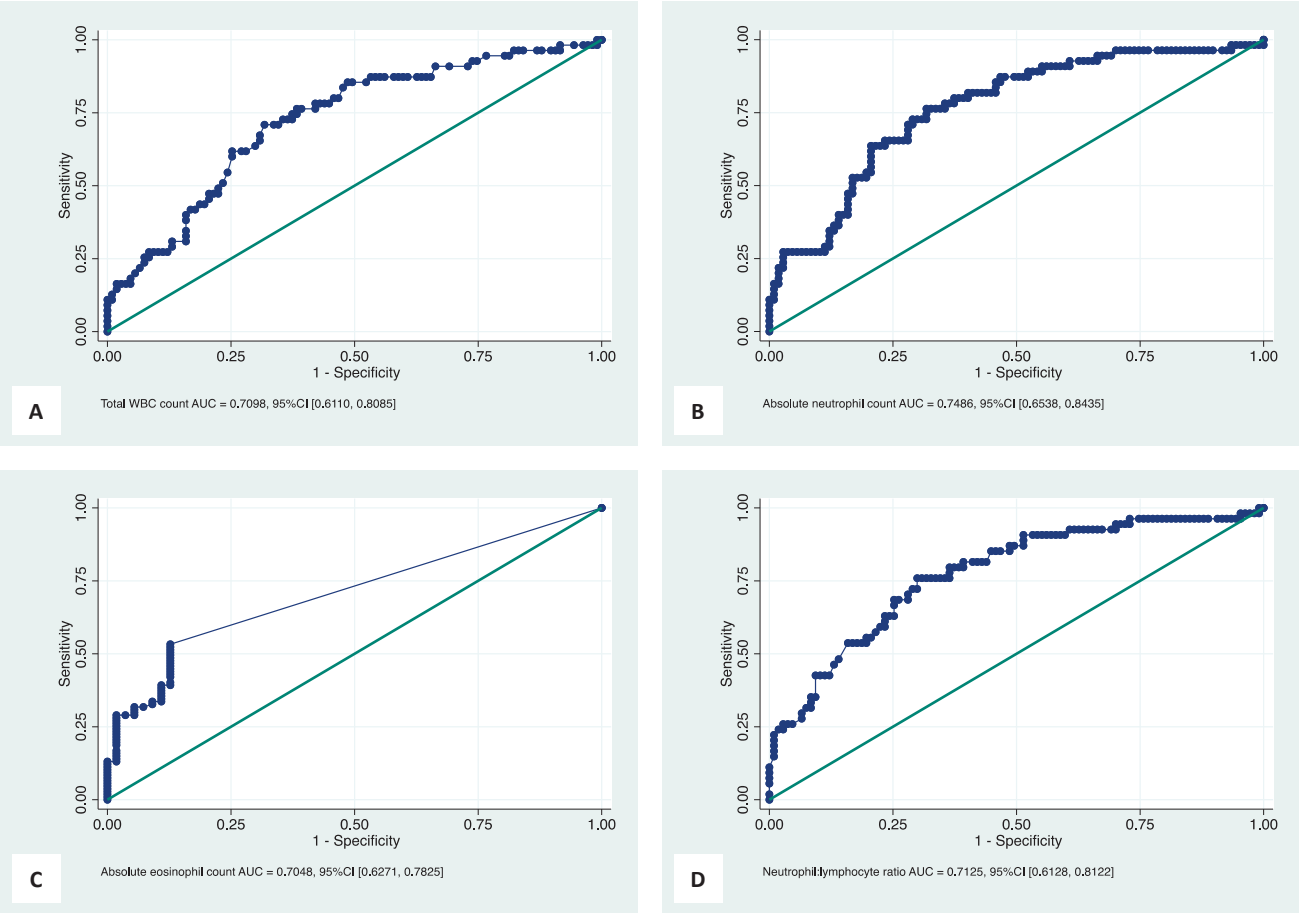

Figure 1. Receiver operating characteristic curves of admission CBC and CPD parameters of in-hospital mortality among admitted COVID-19 patients. **(A)** total WBC count; **(B)** absolute neutrophil count; **(C)** absolute eosinophil count; **(D)** neutrophil:lymphocyte ratio.

Table 5. Cut-off analysis of admission CBC and CPD parameters as predictors of in-hospital mortality among admitted COVID-19 patients

Blood cell parameters	Cut-off (x 10^9/L)	Youden index	Sensitivity		Specificity	
			Estimate	95% CI	Estimate	95% CI
Total WBC count	9.9	0.391	70.9%	57.1, 82.4	66.2%	58.5, 76.9
Absolute neutrophil count	7.3	0.461	76.4%	63.0, 86.8	68.2%	58.5, 76.9
Absolute eosinophil count*	0.006	0.425	53.3%	43.4, 63.0	87.3%	75.5, 94.7
Neutropil:lymphocyte ratio	7.62	0.481	76.4%	63.0, 86.8	70.1%	60.5, 78.6

*Predicts towards the direction of survival rather than to the direction of in-hospital mortality.

While comparable with results of other studies, the performance of these parameters as early prognostic markers for in-house mortality appears to be less than ideal. Analysis of only the baseline sample may be insufficient to predict the ultimate outcome of patients. Additional monitoring of CBC and CPD parameters taken at various points during admission may give a better picture on their role in predicting patient outcomes. Nonetheless, the study may provide evidence that some these parameters show promise as prognostic markers. Correlation with other laboratory parameters and most importantly clinical context remains the gold standard in patient management.

CONCLUSION AND RECOMMENDATION

This study shows that baseline CBC and CPD parameters show weak correlation with disease severity on admission. The total WBC count, ANC, and NLR are statistically significant predictors for in-hospital mortality, while AEC predicts towards the direction of survival. The sensitivities and specificities of the cut off for these parameters are less than ideal. Correlation with clinical and other laboratory parameters is still recommended. For future studies, the authors recommend monitoring CBC and CPD parameters at different time points during the patients' hospital course.

STATEMENT OF AUTHORSHIP

The authors certified fulfilment of ICMJE authorship criteria.

AUTHOR DISCLOSURE

The authors declared no conflict of interest.

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