

Complete Blood Count and Peripheral Smear Findings in Patients with COVID-19: An Institutional Study

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Abstract

Background: Coronavirus disease 19 (COVID-19) 1st emerged in Wuhan province of China, caused by the *SARS-Cov-2* virus in December 2019. COVID-19 has systemic manifestations, including hematologic manifestations. Complete blood count (CBC) has been recommended as a valuable tool for patient monitoring.

Materials and Methods: Our study was an ambispective study on COVID-19-positive patients whose complete blood count samples and peripheral smears. We analysed 700 patients with COVID-19 and recruited perfectly matched controls (COVID Negative) of similar age and gender.

Results: The study included 700 cases (125 cases CBC with peripheral smears and the remaining 575 with only CBC) with an additional 60 COVID PCR negative and 60 COVID-recovered patients. COVID-19-positive patients had a mean age of 49.5 years with an M: F ratio. ESR mean value was 36mm in 1st hr. TLC count of $10.06 \times 10^3/\mu\text{L}$ whereas the COVID recovered, and COVID-negative patients had TLC in the mean of $7.32 \times 10^3/\mu\text{L}$ & $8.03 \times 10^3/\mu\text{L}$ and was significant (p-value 0.000). A comparison of leucocyte counts among the three groups showed that the neutrophil, lymphocyte, monocyte, eosinophil count and their absolute values being statistically significant. Platelet count, MPV, and PDW were also significant among the three groups of patients.

Conclusion: Peripheral smear evaluation of COVID-19 patients could provide an insight into the severity of disease and multi-organ involvement. Morphological analysis by a trained pathologist cannot be entirely replaced by artificial intelligence. When looked at by a trained pathologist, subtle shape, size, and morphology variations can help adequately manage patients.

Keywords: COVID-19; blood count; blood smear; RT-PCR

Introduction

The novel coronavirus pandemic, known as COVID-19, is caused by the *SARS-CoV-2* virus, started in early December 2019 in Wuhan, China, and spread rapidly worldwide. WHO described it as a viral pneumonia pandemic with a global health emergency. Early identification of virus carriers is vital to prevent their spread and more efficiently control disease progression. [?, ?, ?] Knowledge about the widely available test can help indicate the possible COVID-19 infection and control of the pandemic. [?] Molecular testing is available, but limited access to these tests and the requirement of specialised equipment/expertise are the limitations. Serological tests and inflammatory markers, i.e. C reactive protein, D-Dimer, albumin, LDH, and ferritin, have been used to estimate the severity of infection, albeit with financial implications. [?, ?]

Complete blood count (CBC) with a peripheral smear (PS) has been used to predict the infection, with leucocytes and platelets being the most commonly affected cells. [?] Features such as thrombocytopenia and leucopenia with low neutrophil and leucocyte counts are seen in COVID-19 patients and are directly proportional to the severity of the disease. [?, ?, ?]

Objectives of the study

Primary Objective: To assess the CBC changes in RT-PCR-confirmed COVID-19 patients within three days of symptom onset or three days of RT-PCR-positive results in asymptomatic cases.

Secondary Objectives: To assess the smear findings in RT-PCR-confirmed COVID-19 patients within three days of symptom onset or three days of RT-PCR positive result, in case of asymptomatic cases. To compare the CBC and peripheral smear findings among symptomatic and asymptomatic cases. To compare the CBC and peripheral smear findings of three groups.

Material & Methodology

This is an ambispective, observational study designed to assess retrospective and prospective data of haematological findings in COVID-19 positive patients, COVID-19 negative patients and COVID-19 recovered cases, respectively.

The retrospective component of the study will comprise data analysis of the haematological profile (CBC & PS) of COVID-19-positive patients and COVID-19-negative patients attending OPD.

The prospective component of the study will comprise data analysis of the haematological profile (complete blood count and peripheral smear) of COVID-19 recovered cases attending OPD for follow-up or any complaint(s). All patients consent was taken at the time of admission at hospital for use of the sample for study purpose. The study was conducted after obtaining approval from the Institutional Ethics committee AIIMS/MG/IEC/2021-22/115.

Hence, three study groups were assessed for haematological parameters, matched by five-year age groups, and only available patient records with haematological profiles (complete blood count and peripheral smear) as ordered by treating doctors will be analysed without ordering for these tests by the study investigators.

Study Population

The study population will consist of all consecutive patients with a COVID-19 test report between July 2020 and June 2021 (12-month reference period).

We divided the patients into three groups- RT-PCR-confirmed COVID-19 positive, RT-PCR COVID-19 negative, and COVID-19 recovered/convalescent patients who were previously RT-PCR positive. Patients without the COVID-19 RT-PCR report or any other haematological disorders were excluded from the study.

Results

The study included a total 700 RT-PCR COVID-19-positive cases. The most common age group to be hospitalised were in the 5th decade, with a mean of 49.6 years. We had 480 (68.5%) male and 220 (31.5%) female patients. ?? Cough and fever were the most common clinical presenting features. Fever was present in 61 (48.8%), difficulty in breathing in 11 (8.8%), cough in 29 (23.2%), diarrhoea in 13 (10.4%), sore throat in 4 (3.2%), cold in 11 (8.8%), and weakness in 4 (3.2%) cases. The interval of fever to sample collection ranged from 2 to 5 days, the most common being 3rd day. The mean ESR value in the COVID-positive cases of the study was 36.7 mm in 1st hour. Complete blood count parameters were evaluated among the COVID-positive group- total red blood cell count ranged from 1.24 to 7.0 x 10⁶/μL, with a mean of 4.62 x 10⁶/μL (p-value 0.004), haemoglobin value ranging from 4.7-21.4g/dL with a mean of 13.2g/dL, haematocrit of range of 12.8-65.7% and a mean of 38.6%. The mean cell volume (MCV) was 39.9 - 114.9 fL, and the mean value of 96fL. The mean corpuscular haemoglobin (MCH) is 18.7 to 40 pg, and the mean value is 29.6 pg. The mean cell haemoglobin concentration (MCHC) values ranged from 30.3-37.9g/dL and a mean of 34.3g/dL (p-value 0.007). The red cell distribution width coefficient of variation (RDW-CV) ranged from 10.9 to 29.9%, with a mean of 14.41% (p-value 0.001). ??, ??

The platelet parameters ranged from 38 *10³/μL to 760 *10³/μL with a mean of 255 *10³/μL (p-value 0.031). Plateletcrit (PCT) ranged from 0.05 to 0.71 μm³ with a mean of 0.26 μm³. Mean platelet volume (MPV) was in the range of 7.9 to 16.9 μm³ (Mean 10.28 μm³) (p-value 0.000). Platelet distribution width (PDW) had a range of 9.5 to 35 % (Mean 15.9 %) (p-value 0.000). P-LCC had a range of 15 to 229*10³/μL (Mean 71.79*10³/μL) and P-LCR in a range of 12.7 to 62.4% (Mean 29.69%) (p-value 0.000). ??, ??

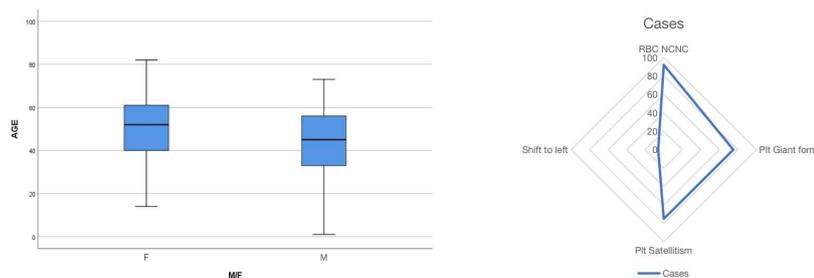


Figure 1: Box & whisker chart showing the age group of presentation, radar chart showing the morphological features.

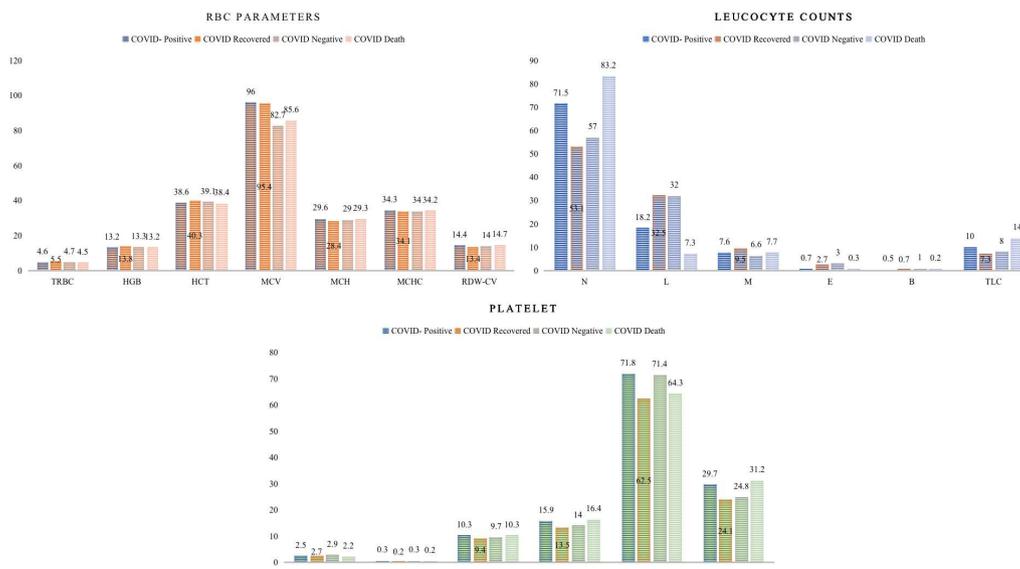


Figure 2: Chart showing the RBC, leucocyte & platelet indices in COVID patients.

Table 1: Complete blood count red blood cell parameters in COVID-19-positive patients.

Parameter	COVID-19 (n=700)	Positive	COVID-19 Recovered (n=60)	COVID-19 Negative (n=60)	p-value
RBC count (x 10 ⁶ /μL)	4.62	N/A	N/A	N/A	0.004
Haemoglobin (g/dL)	13.2	N/A	N/A	N/A	N/A
Haematocrit (%)	38.6	N/A	N/A	N/A	N/A
MCV (fL)	96	N/A	N/A	N/A	N/A
MCH (pg)	29.6	N/A	N/A	N/A	N/A
MCHC (g/dL)	34.3	N/A	N/A	N/A	0.007
RDW-CV (%)	14.41	N/A	14.06	N/A	0.001

Table 2: Platelet parameters in COVID-19-positive patients.

Parameter	COVID-19 (n=700)	Positive	COVID-19 Recovered (n=60)	COVID-19 Negative (n=60)	p-value
Platelet count (x 10 ³ /μL)	255	N/A	N/A	N/A	0.031
PCT (μm ³)	0.26	N/A	N/A	N/A	N/A
MPV (μm ³)	10.28	N/A	N/A	N/A	0.000
PDW (%)	15.9	N/A	N/A	N/A	0.000
P-LCC (x 10 ³ /μL)	71.79	N/A	N/A	N/A	N/A
P-LCR (%)	29.69	N/A	N/A	N/A	0.000

Among the leucocytes, total leucocyte counts were 1.07 to 51.9 *10³/μL and a mean of 10.06 * 10³/μL (p-value 0.000). The neutrophils % and absolute neutrophil counts were 12.8 to 95.2 *10³/μL and 4.8 to 40 %, respectively, with a mean of 71.47 *10³/μL and 7.78% (p-value 0.000). The lymphocyte % and abs lymphocyte counts were 1.2 to 67.4 *10³/μL and 0.25 to 11.2 %, respectively, with a mean of 18.25* 10³/μL and 1.33 %, respectively (p-value 0.000). The monocyte counts and absolute monocyte value were in the range of 0.2 to 25.3* 10³/μL and 0.01 to 3.2%, respectively, with a mean of 7.58

10³/μL and 0.75%, respectively (p-value 0.000). The eosinophil and absolute counts ranged from 0.0 to 9.4 10³/μL and 0 to 2.45%, respectively, with mean values of 0.67 *10³/μL and 0.06%, respectively (p-value 0.000). The basophils and absolute counts ranged from 0 to 2.3*10³/μL and 0 to 1%, respectively, with a mean of 0.48*10³/μL and 0.02 %, respectively (p-value 0.000). There were atypical cells in the machine counts and smears in the range of 0.1 to 13.7 *10³/μL (p-value 0.000). ??, ??

Table 3: Leucocyte parameters in COVID-19-positive patients.

Parameter	COVID-19 Positive (n=700)	COVID-19 Recov-ered (n=60)	COVID-19 Negative (n=60)	p-value
TLC (x 10 ³ /μL)	10.06	7.32	8.03	0.000
Neutrophils (%)	71.47	N/A	N/A	0.000
Absolute Neutrophil count (x 10 ³ /μL)	7.78	3.98	4.63	0.000
Lymphocytes (%)	18.25	N/A	N/A	0.000
Absolute Lymphocyte count (x 10 ³ /μL)	1.33	2.85	2.53	0.000
Monocytes (%)	7.58	N/A	N/A	0.000
Absolute Monocyte count (x 10 ³ /μL)	0.75	0.83	N/A	0.000
Eosinophils (%)	0.67	N/A	N/A	0.000
Absolute Eosinophil count (x 10 ³ /μL)	0.06	2.68	2.94	0.000
Basophils (%)	0.48	N/A	N/A	0.000
Absolute Basophil count (x 10 ³ /μL)	0.02	0.06	0.08	0.000
Atypical cells (x 10 ³ /μL)	0.1 to 13.7	N/A	N/A	0.000

The parameters such as gender, ESR, Hb, HCT, MCV, MCH, PCT & and P-LCC were not statistically significant in our study. The rest of the hematological parameters had a statistically significant p-value.

The peripheral smears of 125 cases for RBCs, WBCs and platelets morphology were analyzed. The red cell morphology was predominantly normocytic normochromic in 115 (92%) cases. Platelets showed giant forms in 94 (75.2%), and platelet satellitism was seen in 94 (75.2%) cases. Shift to the left was seen in 8 (6.4%) cases. ??

The neutrophils showed hypo granulation in 113 (90.4%), hypopigmentation was noted in all 125, with clumped chromatin in 60 (48%), C-shaped nucleus in 116 (92.8%), nuclear ring formation in 89 (71.2%), cytoplasmic vacuolation in 122 (97.6%), aberrant cytoplasmic projections in 115 (92%), smudged nucleus in all 125, and apoptotic nuclei in 51 (40.8%) cases. ??

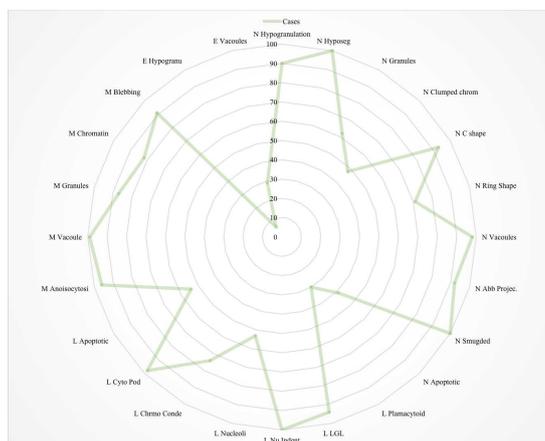


Figure 3: Radar diagram with various morphological changes in blood cells.

The lymphocytes had a plasmacytoid form in 37 (29.6%) cases, and there were large granular lymphocytes in 118 (94.4%) cases, with nuclear indentation in all 125 cases. Prominent nucleoli were identified in 66 (52.8%) cases, chromatin condensation in 92 (73.6%) cases, cytoplasmic projections in 122 (97.6%) cases, and apoptotic lymphocytes in 67 (53.6%) cases. ??

The monocytes had anisocytosis in 120 (96%), cytoplasmic vacuolation in 124 (99.2%), and cytoplasmic granules in 108 (86.4%) cases. The chromatin of monocytes was predominantly open type in 105 (84%) cases, with blebbing in 114 (91.2%) cases.??

The eosinophils showed hypo granulation in 117 (93.6%) cases, with vacuolation in 36 (28.8%) cases. ??

Our study had a mean TLC count of 10.06 *10³/μL whereas the COVID recovered, and COVID-negative patients had TLC in the mean of 7.32*10³/μL & 8.03*10³/μL and was significant (p-value 0.000). A comparison of leucocyte counts in

COVID-19-positive patients with COVID-19 recovered and COVID-19-negative patients showed that the neutrophil count, lymphocyte, monocyte, eosinophil counts, and absolute values were statistically significant. ??, ?? Platelet count, mean platelet volume and platelet distribution width were also significant among the three groups of patients.

Among the 700 cases who were COVID-19 positive, 40 patients had a severe form of the infection and did not survive. The mean age of this group of patients was 56.4 years, which was higher than the mild disease patients with 49.5 years of mean age. The CBC parameters of these patients showed lower platelet counts ($224.2 \times 10^3/\mu\text{L}$), elevated TLC counts ($14 \times 10^3/\mu\text{L}$), neutrophilia (83%; absolute count $12 \times 10^3/\mu\text{L}$), severe lymphopenia (7.3%; absolute count $0.7 \times 10^3/\mu\text{L}$) and severe eosinopenia (0.3%; absolute count $0.01 \times 10^3/\mu\text{L}$). These values were significantly abnormal compared to the COVID-19-positive but mild to moderate patients who had survived the infection. ??

Discussion

The COVID-19 viral disease had 1st reported in Wuhan city of China, and spread globally since then. The pathogenesis behind the infection was not completely understood. The causative agent *SARS-CoV-2* has some genomic similarity with *SARS-CoV*. [?] The virus infects the host cell with an expression of angiotensin-converting enzyme 2 (ACE-2) receptors in alveoli, alveolar macrophages, & endothelial cells. ACE-2 and transmembrane protease serine 2 (TMPRSS2) receptors are the sites of host cell death by monocyte/macrophage activation, T-cell activation, cytokine release and B cell-mediated antibody production. [?]

The laboratory results have shown that COVID-19 patients may have lymphopenia, leucocytosis, neutrophilia, monocytosis, and eosinopenia. [?] Similar findings were observed in our study also. Lymphopenia is the prominent hematologic finding for predicting disease severity in *SARS-CoV-2* and other *SARS-CoV* patients. [?] The development of lymphopenia in COVID-19 patients may be due to the virus-causing ACE-2 receptor expression on lymphocytes, apoptosis due to cytokine-induced, and various metabolic products causing lymphocyte depletion. [?] Flow cytometry can be used to detect depleted absolute T lymphocyte cells. [?] Our study has shown reduced lymphocyte counts compared to the control and recovered groups.

PS in COVID-19 have rarely been reported in the literature. Zini *et al.* reported the presence of Acquired Pelger-Huet anomaly (APHA), abnormal neutrophilic granulation, homologation/monolobate neutrophils, granulocytic shift to the left, abnormal platelets, apoptotic cells and reactive lymphocytes. [?, ?] Pelger-Huet anomaly is a benign hereditary condition where mutations of the lamin B receptor (LBR) cause the hypo-segmentation of neutrophils with dense chromatin. The changes in neutrophil morphology disappeared entirely after one week of anti-retroviral / anti-inflammatory therapy. [?]

Our study highlights the quantitative data from CBC values and PS morphological changes. This is the first of its kind to be reported in India considering the number of samples evaluated and various CBC parameters. Our study also analysed the correlation between disease severity with morphological changes on peripheral smear *i.e.* Leucocytic changes such as atypical lymphocytes, large monocytes with cytoplasmic vacuoles, and hypogranular neutrophil cytoplasm of the peripheral blood smears. Although our study had only 125 cases with peripheral smear findings, it concurred with other studies by Elemam *et al.*, Zhang *et al.* Zini *et al.* reported various peripheral smear morphology changes, specifically in neutrophils and lymphocytes.

Even with the advances in COVID-19 treatment, sparse information is available regarding the various morphological changes in blood smears of infected persons and their clinical outcomes. Critically lethal patients had predominantly normochromic normocytic anaemia in a study done by Eleman *et al.* Similar findings were noted in our study, with 74% being a normochromic normocytic picture. [?] The total red cell count in our COVID patients was $4.65 \times 10^6/\mu\text{L}$, which was lower than the COVID-19-negative patients or recovered patients. Haemoglobin values tend to decrease with disease progression. [?] Our study had severe anaemia in 0.6% of patients, 6% with moderate anaemia and 93.4% in the mild anaemia group. The moderate to severe anaemia group had a more extended hospital stay. The increased degree of anisocytosis has been reported in literature represented by the RDW-CV, which has been a reliable, though not specific, marker of worse prognosis. [?, ?] Our study had an RDW-CV of 14.41% in the positive group compared to 14.06% in the control group (p-value 0.001). RBC morphology changes have only occasionally been reported in the literature. [?]

Total leucocyte counts may be low during the initial days of infection (1-14 days). After 7 days, the illness is governed by inflammatory mediators and cytokines, leading to a cytokine storm. [?] The severity of the disease depends on the extent of the inflammatory response, and patients with hyperinflammatory syndrome develop neutrophilic leucocytosis and lymphopenia. [?] Our study had a mean TLC count of $10.06 \times 10^3/\mu\text{L}$ whereas the COVID recovered, and COVID-negative patients had TLC in the mean of $7.32 \times 10^3/\mu\text{L}$ & $8.03 \times 10^3/\mu\text{L}$ and was significant (p-value 0.000). Even the neutrophil count in positive patients was $7.78 \times 10^3/\mu\text{L}$ compared to other groups of patients with $3.98 \times 10^3/\mu\text{L}$ and $4.63 \times 10^3/\mu\text{L}$, respectively, which was significant (p-value 0.000). The neutrophil abnormalities in morphology have been consistently seen in COVID-19. The common findings in various studies include: [?, ?, ?] ??

Hypergranular cytoplasm (97% in literature and our study 62%). Hypogranular cytoplasm (our study 90%). Dohle bodies,

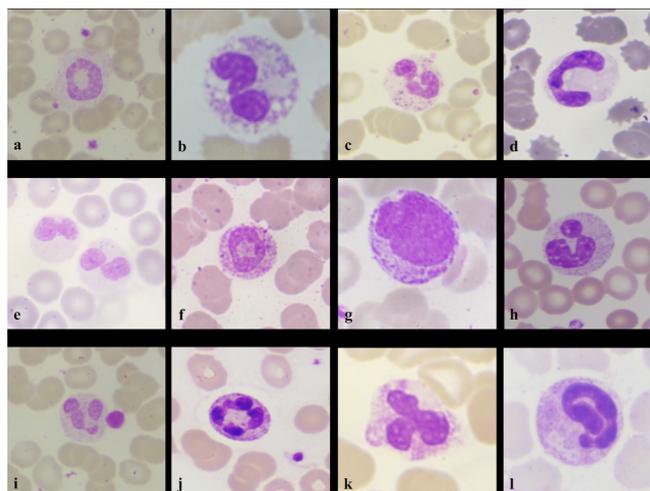


Figure 4: Neutrophilic morphological changes - ring form (a), intracytoplasmic vacuoles (b), fetus form (c), band form (d), pseudo-Pelger-Huet nuclei (e), round (f), myeloid precursor (g), drumstick (h), hypogranulation platelet satellitism (i), ring form with condensed chromatin (j), tripolar (k), serpentine-like (l) (Leishman stain, x100).

Cytoplasmic blue-green inclusions/death cells. Cytoplasmic vacuoles (95% in literature and our study 98%). Unusual nuclear profiles (rounded, c shape, fetus-like, ring shape) (our study 92%). Hypopigmentation (our study 100%). Hyperdense chromatin, karyorrhexis and karyolysis, apoptotic forms, smudged cells, giant forms and shift to the left.

COVID-19 patients usually have lymphocytopenia at the time of admission, and it's associated with unfavorable progression. It has been reported in many cases since the beginning of the COVID-19 infection in China. The severity increases even more in patients with assisted respiration in ICU patients. [?, ?] Pozdnyakova et al. noted a continuing decline in the absolute lymphocyte count from ICU admission to demise. [?] Our study also had reduced absolute lymphocyte counts in COVID patients ($1.38 \times 10^3/\mu\text{L}$). In contrast, the COVID-recovered ($2.85 \times 10^3/\mu\text{L}$) and COVID-negative ($2.53 \times 10^3/\mu\text{L}$) patients had somewhat better counts and were significant (p-value 0.000).

The morphological changes in lymphocytes have been considered by authors as atypical, reactive, activated, variant or pleomorphic and are known to be seen in *EBV* infection or *CMV*. [?, ?] The term reactive has been suggested to favor benign etiology over atypical, which, as per ICSH, is suggestive of malignancy or clonal etiology. [?] Our study also focused on recognizing these cells as reactive change, not atypical. COVID-19 patients have various morphological changes- [?] ??

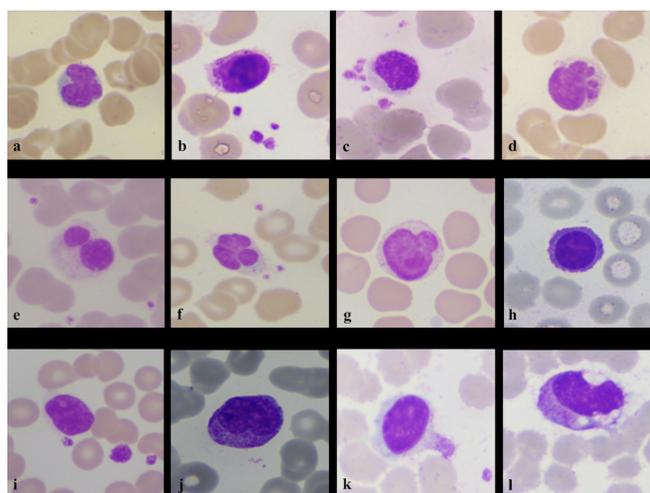


Figure 5: Lymphocyte morphological changes- irregular nuclear membrane (a), cytoplasmic tailing (b), irregular nuclear membrane with platelet satellitism (c), multiple blebs/baby feet (d), nuclear budding (e), nuclear blebs with platelet satellitism (f), cytoplasmic outpouching/cytoplasmic pod (g), basophilic cytoplasm (h), atypical large cells with prominent nucleoli and platelet satellitism (i), large lymphocytes with nuclear indentation (j), cytoplasmic pod and granularity (k), large lymphocyte with cytoplasmic vacuolation (l). (Leishman stain, x100).

Large lymphocytes with increased pale or blue cytoplasm. (Our study 53%). Lymphoplasmacytoid cells have eccentric nuclei and deep blue cytoplasm. (our study 30%). Large granular lymphocytes (LGLs), (our study 94.4%). Other features i.e. cytoplasmic vacuolation, lobulated nuclei, spongy chromatin, apoptotic lymphocytes (our study 54%), presence of pseudopods (our study 98%) and smudge cells, etc. An increased NLR has been a significant predictor of prognosis and

survival in COVID-19 patients. [?]

Monocytopenia is a feature described in the literature with reactive forms that are usually not seen in normal conditions. [?] Features such as increased size, abundant greyish-blue cytoplasm, fine cytoplasmic granulations and a striking feature of cytoplasmic vacuolization were reported by many authors [?] (our study 99%). Interleukin-8, a pro-inflammatory marker, has been reported to be associated with monocyte morphological changes. [?] The absolute values of monocyte count in our study were $0.75 \times 10^3/\mu\text{L}$ in COVID-19 patients and $0.83 \times 10^3/\mu\text{L}$ in COVID-19 recovered patients and were statistically significant (p-value 0.000) ??

Eosinophil changes have significant variation in COVID-19 patients and are of substantial significance. It has been reported that eosinopenia is more common in ICU-admitted or fatal cases. [?] Morphological changes "dysmorphism" (trilobed, hypo granular cytoplasm, vacuolations) in eosinophils are rarely reported in the literature. [?] However, the absolute eosinophil counts in COVID-19 were $0.06 \times 10^3/\mu\text{L}$, whereas $2.68 \times 10^3/\mu\text{L}$ and $2.94 \times 10^3/\mu\text{L}$ in recovered and negative patients, respectively. (p-value 0.000). Chen et al. found that absolute basophil counts were lower in COVID-19 patients than in the control group. [?] Similar findings were found in our study with COVID-19 patients having $0.02 \times 10^3/\mu\text{L}$ absolute values as compared to $0.06 \times 10^3/\mu\text{L}$ in recovered patients and negative group $0.08 \times 10^3/\mu\text{L}$. No specific morphological abnormalities were found in basophils.

Platelet counts have been reported to be expected or decreased at admission to the hospital. [?] Average platelet count was noted in 86% of cases in our study, while only 11% had low platelet counts. Morphological changes in platelets have been described in the literature. [?] ??

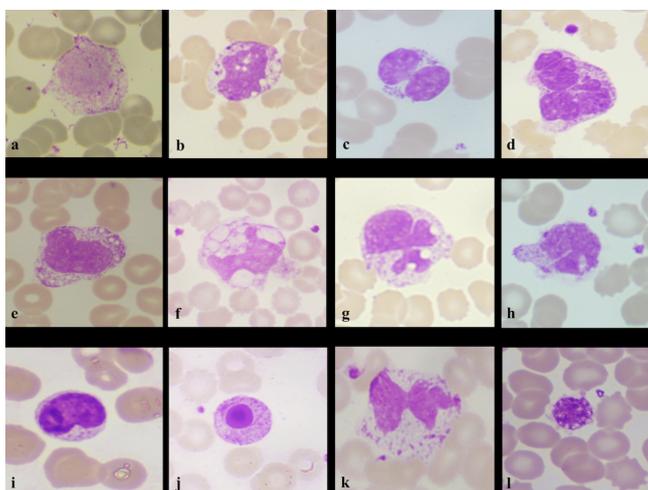


Figure 6: Monocyte and platelet morphological change- irregular cytoplasm outline (a), cytoplasmic vacuolation (b), nuclear bleb (c), tripolar nuclear branching (d), intracytoplasmic vacuolation (e,f), staghorn nuclei (g), U shaped nuclei with cytoplasmic projection and platelet satellitism (h), bean-shaped (i), apoptotic nuclei (j), bilobed nuclei of smudge cell (k), and platelet changes in form of giant platelets (l). (Leishman stain, x100).

. Giant platelets (our study 75%), Hyperchromatic granules, Pseudopoidal protusions, Satellitism (our study 75%). Platelet parameters, i.e. count, mean platelet counts, PDW, PLCC, were statistically significant in our study. (p-value of 0.031, 0.000 and 0.000).

A peripheral blood smear is an inexpensive, easily performed, and rapid test. Increased Pseudo-Pelger-Huet anomaly/mature lymphocyte rate suggests a severe stage disease, while high initial mature lymphocyte and monocytes with vacuoles rates at the time of diagnosis may be an indicator of shortened duration of hospitalization. The morphological findings in PS are not an direct proof of COVID 19 infection. However the findings will help in triage or monitoring, severity of the disease and follow up of patients.

Limitations of the study included the lack of taking other co-morbidities into account, which can cause lower platelet and haemoglobin counts. Even the method of smear preparation and the effect of sample storage.

Conclusion

Our study was the first with almost 700 samples inclusive of 125 COVID-positive cases and an additional 120 control groups of patients with morphological changes analysis. Peripheral smear evaluation at the time of diagnosis in COVID-19 patients could provide insight into the disease severity and organ involvement. Morphological analysis by a trained pathologist cannot be entirely replaced by AI. When looked at by a trained pathologist, subtle variations in shape, size, and morphology can help adequately manage patients.

Declarations

Funding sources: The study received no funding from any sources.

Conflict of interest statement: The authors declare no conflict of interest.

Ethics approval: The study was conducted after obtaining approval from the Institutional Ethics Committee of AIIMS, Mangalagiri (AIIMS/MG/IEC/2021-22/115).

Consent to participate & publish: Written informed consent to publish was taken from the patients involved in the study.

Data Availability Statement: All data generated or analysed during this study are included in this article. Further inquiries can be directed to the corresponding author.

Code availability: Nil

Author contributions: T.S. carried out the literature search, data acquisition, data analysis, clinical study, and manuscript preparation and will stand as guarantor. A.S. carried out the literature search and data acquisition. R.A. carried out concepts, design and data analysis. All the authors have read and approved the final manuscript.

Abbreviations: ACE-2: Angiotensin-converting enzyme 2, APHA: Acquired Pelger-Huet anomaly, CBC: Complete blood count, COVID-19, ESR: Erythrocyte sedimentation rate, LDH: Lactate dehydrogenase, LBR: Lamin B receptor, LGL: Large granular lymphocytes, MCV: Mean cell volume, MCH: Mean corpuscular haemoglobin, MCHC: Mean cell haemoglobin concentration, MPV: Mean platelet volume, OPD: Outpatient department, PCT: Plateletcrit, PDW: Platelet distribution width, PS: Peripheral smear, RT-PCR: Real time polymerase chain reaction, TLC: Total leucocyte count, TMPRSS2: Transmembrane protease serine 2, WHO: World health organization.

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