

Haematological, Inflammatory and Coagulation Profiles in Pregnant Women with COVID-19 Infection: A Prospective Case Control Study in a Tertiary Care Centre

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ABSTRACT

Background: COVID-19 is associated with systemic haematological and inflammatory alterations that may be superimposed on the physiological hypercoagulability of pregnancy. Comparative case-control data combining haematological, coagulation and inflammatory parameters in Indian obstetric populations are limited. **Objectives:** To compare haematological, coagulation, inflammatory and biochemical parameters between COVID-19-positive and COVID-19-negative pregnant women in the third trimester. **Methods:** A prospective case-control study was conducted in the Department of Obstetrics and Gynaecology of a tertiary care teaching hospital in Shivamogga, Karnataka. Third-trimester pregnant women with and without COVID-19 (confirmed by RT-PCR or rapid antigen test) were compared for hemoglobin, total and differential leucocyte counts, platelet count, PT, APTT, INR, D-dimer, LDH, CRP and serum ferritin. Continuous variables were summarised as mean $\pm$ SD or median (IQR) according to distribution and compared using the independent t-test or Mann-Whitney U test; categorical variables were compared using the chi-square or Fisher's exact test. Two-sided $P < 0.05$ was considered significant. **Results:** The dataset comprised 124 pregnant women (62 COVID-positive, 62 COVID-negative), exceeding the 120 participants (60 per group) originally proposed; this discrepancy is noted explicitly. Age, gestational age and gravidity did not differ between groups. COVID-positive women had significantly higher total leucocyte count (mean 9585 ± 3047 vs 8091 ± 2232 cells/cu mm; $P = 0.002$), higher neutrophil percentage (median 74.0% vs 59.5%; $P < 0.001$), lower lymphocyte percentage (median 20.0% vs 28.0%; $P < 0.001$), higher neutrophil-to-lymphocyte ratio (median 3.70 vs 2.15; $P < 0.001$) and more frequent qualitatively positive CRP (40.3% vs 4.8%; $P < 0.001$) than COVID-negative women. Haemoglobin, platelet count, PT, APTT, INR, D-dimer, LDH and serum ferritin did not differ significantly, although D-dimer and ferritin showed a non-significant upward trend in the COVID-positive group. **Conclusions:** Pregnant women with COVID-19 showed neutrophilic leucocytosis, relative lymphopenia, elevated NLR and higher CRP positivity compared with COVID-negative pregnant women, consistent with a systemic inflammatory response. Coagulation parameters were not significantly deranged in this cohort. These are observational associations that do not establish causation; placental correlation requires dedicated histopathological data.

Keywords: COVID-19; pregnancy; third trimester; haematological parameters; neutrophil-to-lymphocyte ratio; case-control studies; placenta

INTRODUCTION

Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infection extends beyond the respiratory

tract, with recognised involvement of the gastrointestinal, neurological, cardiovascular, haematological, genitourinary and immune systems¹.

Because the systemic manifestations of COVID-19 are, in part, mediated through the haematological and coagulation systems, characterisation of the peripheral blood profile has been proposed as an accessible window into disease pathophysiology². A substantial proportion of patients with severe COVID-19 develop coagulation abnormalities, and marked elevation of D-dimer has been associated with a heightened risk of thrombotic complications³. Postmortem and biopsy-based histopathological studies have shown organ-level changes attributable to SARS-CoV-2, although hypoxic and other secondary metabolic effects cannot always be separated from a direct cytopathic viral effect⁴.

Pregnancy is itself a physiologically hypercoagulable state, with progressive increases in clotting factors and fibrinolytic markers such as D-dimer across gestation⁵. Superimposition of a COVID-19-associated inflammatory and pro-thrombotic state on this baseline hypercoagulability has raised concern about additive thrombotic risk in pregnant women. Lymphopenia is a frequently reported finding in COVID-19 and has been attributed to several, non-mutually-exclusive mechanisms, including direct lymphocyte infection, lymphoid organ injury, cytokine-mediated apoptosis and metabolic suppression of lymphocyte proliferation⁶. Because pregnancy itself alters baseline leucocyte indices, ratios such as the neutrophil-to-lymphocyte ratio (NLR) have been proposed as more stable inflammatory markers in pregnant populations, and trimester-specific reference ranges for NLR in normal pregnancy have been described⁷.

Indian tertiary care experience with COVID-19 in pregnancy has largely focused on maternal-fetal outcomes and viral load rather than on a detailed comparative haematological and coagulation profile against a contemporaneous COVID-negative control group⁸. The placenta, as the maternal-fetal interface, has attracted separate attention: a structured review of placental morphology following SARS-CoV-2 infection reported an increased frequency of maternal and fetal vascular malperfusion lesions across pooled series, evaluated using standardised Amsterdam Consensus criteria^{9,10}. A large meta-analysis of haematological and immunological markers in COVID-19 (not restricted to pregnancy) found that elevated white cell and neutrophil counts, prolonged prothrombin time and elevated D-dimer were each associated with greater odds of severe disease¹¹.

Taken together, the existing literature establishes that COVID-19 alters haematological and coagulation parameters in general populations, and that placental vascular lesions have been reported in COVID-19-affected pregnancies studied elsewhere; however, comparative case-control data combining haematological, coagulation and inflammatory

parameters in a South Indian tertiary obstetric population remain limited. This is a locally relevant comparison rather than a claim of a major unaddressed international gap. The present study was conducted to compare haematological, coagulation, inflammatory and biochemical parameters between COVID-19-positive and COVID-19-negative pregnant women presenting in the third trimester at a single tertiary care centre. Individual-level placental histopathology, could not be analysed in the present report and is the study limitation.

MATERIALS AND METHODS

Study Design and Setting

This was a prospective case-control study conducted in the Department of Obstetrics and Gynaecology at a tertiary care hospital attached to a medical college in Shivamogga, Karnataka, India.

Participants

Women aged 18–45 years in the third trimester of pregnancy, presenting for delivery with or without labour pain, were eligible. Cases were pregnant women who tested positive for SARS-CoV-2; controls were pregnant women who tested negative. Women in the first or second trimester, those declining consent, those with known haematological or bleeding disorders (including leukaemia and inherited coagulopathies), those with chronic medical illness or pregnancy-induced diabetes or hypertension, and postpartum cases were excluded, as specified in the study protocol. Written informed consent was obtained from all participants.

COVID-19 Diagnosis

SARS-CoV-2 infection status was determined by nasopharyngeal swab testing using either a Rapid Antigen Test (RAT) or Reverse Transcriptase Polymerase Chain Reaction (RT-PCR).

Sample Collection and Laboratory Methods

Venous blood was collected by antecubital venepuncture: approximately 2 mL into an anticoagulant-containing vacutainer for haematological processing and 4 mL into a plain vacutainer for biochemical analysis. Complete blood counts were performed on a Beckman Coulter DxH 600 automated haematology analyser. The differential leucocyte count (neutrophils, lymphocytes, eosinophils, monocytes, basophils), platelet count, PT, APTT, INR, D-dimer, LDH, CRP and serum ferritin were recorded.

The unit of measurement for the platelet count was not explicitly stated in the supplied dataset. Given the numerical range of the recorded values (approximately 1.0–3.9), a unit of $\times 10^5$ cells/cu mm (lakhs/cu mm) is the most plausible convention in an Indian laboratory setting and has been assumed for interpretation; this assumption

requires confirmation against the original laboratory report before submission. The unit for D-dimer was likewise not stated; a unit of $\mu\text{g/mL}$ (FEU) has been assumed from the numeric range but is unconfirmed. CRP was recorded in the supplied dataset as a qualitative binary result (“Positive”/“Negative”) rather than as a continuous concentration; it is reported and analysed as a categorical variable accordingly.

Ethical Considerations

The study was submitted to the institutional ethics committee for ethical clearance and approved. Written informed consent was obtained from all participants as per the protocol.

Statistical Analysis

Data were analysed using Python (pandas and SciPy libraries). The distribution of each continuous variable was assessed within each study group using the Shapiro–Wilk test. Variables approximately normally distributed in both groups (total WBC count, platelet count, PT) were summarised as mean $\pm$ standard deviation (SD) and compared using the independent-samples t-test (Welch correction for unequal variances). All other continuous variables were summarised as median (interquartile range, IQR) and compared using the Mann–Whitney U test. The neutrophil-to-lymphocyte ratio (NLR) was calculated for each participant as the neutrophil percentage divided by the lymphocyte percentage, from the raw differential counts supplied; this derived variable, and the formula used, are stated explicitly. Categorical variables (gravidity, CRP positivity) were summarised as frequency and percentage and compared using the chi-square test or Fisher’s exact test, as appropriate for expected cell counts. A two-sided P value < 0.05 was considered statistically significant; exact P values are reported throughout. Because 16 haematological, coagulation and biochemical comparisons were performed (Table 2), the possibility of type I error inflation from multiple testing is acknowledged, and the borderline results for D-dimer and serum ferritin are interpreted cautiously rather than as confirmed differences. Sensitivity analyses excluding two identified extreme outlier values (one APTT value and one INR value; see Data quality audit) were performed to assess their influence on the corresponding comparisons. No multivariable regression model was constructed; the available variable set and sample size were not judged to support a multivariable model without risking overfitting, and none was specified in the protocol. Reporting followed, insofar as applicable to a

case–control comparison, the general principles of the STROBE statement for observational studies¹², and gestation-specific D-dimer reference data from the general obstetric literature were used as an external comparator in interpreting the observed D-dimer values¹³.

RESULTS

The dataset supplied for analysis contained 124 participants (62 COVID-19-positive and 62 COVID-19-negative), classified using the ‘Covid status’ field. Both groups were exactly balanced at 62 participants each.

Age (median 24.0 vs 26.0 years), gestational age (median 38.0 vs 39.0 weeks) and gravidity (primigravida 50.0% vs 45.2%) were similar between COVID-positive and COVID-negative groups, with no statistically significant differences (Table 1).

Haemoglobin did not differ significantly between groups. The total WBC count was significantly higher in COVID-positive women. The differential count showed a significantly higher neutrophil percentage and a correspondingly lower lymphocyte percentage in COVID-positive women, and the derived neutrophil-to-lymphocyte ratio was significantly higher in this group. Eosinophil and monocyte percentages did not differ significantly (Table 2).

Platelet count, PT, APTT and INR showed no statistically significant differences between groups. Two extreme values – one APTT value and one INR value were identified as probable transcription errors (see Data quality audit); sensitivity analyses excluding these values did not materially change the APTT or INR comparisons (APTT: $P = 0.729$ after exclusion, versus $P = 0.619$ with the value included; INR: $P = 0.702$ after exclusion, versus $P = 0.824$ with the value included).

D-dimer and serum ferritin showed a numerically higher median in the COVID-positive group, but neither difference reached statistical significance at the two-sided 0.05 threshold (D-dimer $P = 0.083$; ferritin $P = 0.051$); these should be regarded as borderline, hypothesis-generating observations rather than confirmed findings, particularly in the context of multiple comparisons. LDH did not differ significantly between groups.

CRP, recorded qualitatively, was positive in 25/62 (40.3%) COVID-positive participants compared with 3/62 (4.8%) COVID-negative participants, a highly significant difference (Fisher’s exact $P < 0.001$).

No placental findings are reported.

Table 1. Baseline demographic and obstetric characteristics of COVID-positive versus COVID-negative pregnant women

Characteristic	COVID-positive (n = 62)	COVID-negative (n = 62)	P value
Age (years), median (IQR)	24.0 (22.0–27.8)	26.0 (22.0–28.0)	0.390
Age (years), range	19–39	19–34	—
Gestational age (weeks), median (IQR)	38.0 (38.0–39.0)	39.0 (38.0–39.0)	0.432
Gestational age (weeks), range	30–41	30–40	—
Primigravida, n (%)	31 (50.0)	28 (45.2)	0.719
Multigravida, n (%)	31 (50.0)	34 (54.8)	0.719

IQR, interquartile range. Age compared by Mann–Whitney U test; gestational age compared by Mann–Whitney U test; gravidity compared by chi-square test.

Table 2. Comparison of haematological, coagulation, inflammatory and biochemical parameters between COVID-positive and COVID-negative pregnant women

Parameter	COVID-positive (n = 62)	COVID-negative (n = 62)	Test	P value
Haemoglobin (g/dL), median (IQR)	11.90 (11.30–12.47)	11.75 (11.22–12.28)	MWU	0.342
Total WBC count (cells/cu mm), mean $\pm$ SD	9585 $\pm$ 3047	8091 $\pm$ 2232	t-test	0.002
Neutrophils (%), median (IQR)	74.0 (69.0–77.0)	59.5 (50.0–66.5)	MWU	<0.001
Lymphocytes (%), median (IQR)	20.0 (16.0–25.0)	28.0 (22.0–32.0)	MWU	<0.001
Eosinophils (%), median (IQR)	3.0 (2.0–4.0)	3.0 (2.0–4.0)	MWU	0.088
Monocytes (%), median (IQR)	2.0 (1.0–3.0)	2.0 (1.0–4.0)	MWU	0.376
NLR, median (IQR)	3.70 (2.80–4.74)	2.15 (1.63–2.69)	MWU	<0.001
Platelet count ($\times 10^5$ /cu mm)*, mean $\pm$ SD	2.24 $\pm$ 0.64	2.33 $\pm$ 0.67	t-test	0.434
PT (seconds), mean $\pm$ SD	12.15 $\pm$ 1.43	11.90 $\pm$ 1.44	t-test	0.325
APTT (seconds), median (IQR)	30.50 (27.12–34.65)	31.40 (27.60–33.40)	MWU	0.619
INR, median (IQR)	1.00 (0.91–1.10)	1.02 (0.91–1.14)	MWU	0.824
D-dimer (μ g/mL, unit assumed)*, median (IQR)	0.51 (0.19–1.16)	0.32 (0.14–0.67)	MWU	0.083
LDH (U/L), median (IQR)	409.5 (267.3–538.5)	391.5 (330.5–589.9)	MWU	0.452
Serum ferritin (ng/mL), median (IQR)	42.95 (29.33–68.35)	34.10 (21.48–54.76)	MWU	0.051
CRP positive, n (%)†	25 (40.3)	3 (4.8)	Fisher exact	<0.001

*SD, standard deviation; IQR, interquartile range; MWU, Mann–Whitney U test; NLR, neutrophil-to-lymphocyte ratio (calculated as neutrophil % / lymphocyte %). *Unit not stated in the supplied dataset; assumed unit shown, see Materials and Methods. †CRP was recorded as a qualitative binary result (Positive/Negative) in the supplied dataset rather than as a continuous concentration and is reported as a proportion, compared by Fisher’s exact test.*

DISCUSSION

In this case–control comparison of third-trimester pregnant women, COVID-19-positive participants showed a pattern of neutrophilic leucocytosis, relative lymphopenia and an elevated neutrophil-to-lymphocyte ratio compared with COVID-negative pregnant women. This pattern is broadly concordant with the general (non-pregnant) COVID-19 literature, in which elevated neutrophil counts and lymphopenia have repeatedly been associated with the presence and severity of infection^{2,11}. Several mechanisms have been proposed for COVID-19-

associated lymphopenia, including direct viral infection of lymphocytes, lymphoid organ injury and cytokine-mediated lymphocyte apoptosis⁶; the present cross-sectional comparison cannot distinguish between these mechanisms and simply documents an association at a single time point around the time of delivery.

Because pregnancy itself alters baseline neutrophil and lymphocyte proportions, with published trimester-specific reference ranges for NLR in uncomplicated pregnancy⁷, the elevated NLR observed here in COVID-positive women should be interpreted against a

pregnancy-adjusted rather than a general-population baseline; the median NLR of 2.15 in the COVID-negative group in the present cohort is broadly consistent with previously reported third-trimester reference values, lending some plausibility to the internal comparison, although the present study was not designed or powered to validate an external reference range.

Platelet count, PT, APTT and INR did not differ significantly between groups in this cohort, and this was robust to sensitivity analysis excluding two extreme, probably erroneous, individual values. This finding differs from reports in non-pregnant COVID-19 cohorts in which prolonged PT and abnormal coagulation indices have been associated with severe disease^{3,11}; a plausible explanation is that the present cohort, drawn from women presenting for delivery rather than from hospitalised or critically unwell patients, was not enriched for severe COVID-19, but disease severity was not recorded in the supplied dataset and this explanation cannot be confirmed. D-dimer showed a numerically higher median in the COVID-positive group that did not reach conventional statistical significance; because D-dimer rises physiologically across gestation and reference ranges are gestation-specific¹³, any interpretation of the present D-dimer values against non-pregnant thresholds would be inappropriate, and the borderline result reported here should not be used to infer a clinically important difference without confirmation in a larger, severity-stratified sample.

Serum ferritin also showed a borderline, non-significant trend towards higher values in the COVID-positive group. Ferritin is a non-specific acute-phase reactant, and elevated CRP positivity (40.3% vs 4.8%; $P < 0.001$) in the COVID-positive group is consistent with the presence of a systemic inflammatory response, in keeping with the general association between elevated inflammatory markers and COVID-19 reported elsewhere¹¹. Because CRP was recorded only as a qualitative binary result in the supplied dataset rather than as a continuous concentration, the magnitude of CRP elevation, and any dose–response relationship with other inflammatory markers, could not be assessed.

With respect to the placenta, prior structured reviews using standardised Amsterdam Consensus terminology have reported that a substantial proportion of placentas from SARS-CoV-2-positive pregnancies show maternal and fetal vascular malperfusion lesions^{9,10}. The present dataset did not include individual-level placental findings, and none should be inferred, about placental morphology, vascular malperfusion, intervillous thrombi, infarction, inflammatory lesions or any other histopathological feature in this cohort. Any placental hypothesis arising from the haematological findings described above remains speculative.

Overall, the pattern of findings neutrophilic leucocytosis,

relative lymphopenia, elevated NLR and higher CRP positivity without significant coagulation derangement is consistent with a systemic inflammatory response to SARS-CoV-2 infection superimposed on pregnancy, rather than with a marked additional hypercoagulable insult in this cohort of women presenting for delivery. These are observational, cross-sectional associations; they do not establish a causal or temporal relationship between infection and any laboratory change, and disease severity, symptom status and timing of infection relative to sampling were not available to further characterise this relationship.

Strengths and Limitations

This study has a prospective case–control design with a contemporaneous COVID-negative comparison group and a reasonably balanced sample size (62 per group). It is, however, a single-centre study, which limits generalisability to other populations and testing practices. Several limitations affect interpretation of the findings:

Sample size and power: the realised sample size ($n = 124$) exceeds the protocol's planned 120, and no formal power calculation is reported in the supplied protocol; some comparisons (for example, D-dimer and ferritin) may be underpowered to detect a true difference of modest effect size.

Disease severity, symptom status, vaccination status and treatment: none of these variables were available in the supplied dataset, precluding stratified analysis and limiting the clinical interpretability of the haematological differences observed.

Timing of infection: the interval between COVID-19 diagnosis and blood sampling, and the trimester of initial infection (if different from the trimester of sampling), were not recorded.

Gestational-age restriction: enrolment was restricted to the third trimester, so findings cannot be extrapolated to earlier pregnancy.

Laboratory measurement limitations: the units for platelet count and D-dimer were not stated and have been assumed (see Materials and Methods); CRP was recorded only as a qualitative binary result, preventing quantitative comparison and dose–response analysis; and differential leucocyte percentages did not consistently sum to 100% across records, indicating rounding or transcription inconsistency that affects the differential-count-based variables generally (see Data quality audit).

Raw/suspicious data values: two extreme, physiologically implausible individual values (APTT and INR) were retained in the primary analysis in line with a conservative data-handling approach; sensitivity analyses excluding these values did not change the conclusions, but their presence signals a broader risk of undetected transcription error elsewhere in the dataset.

Absence of placental pathology data: individual-level placental histopathological findings, though planned in the protocol, were not available for analysis; no placental conclusions can therefore be drawn from the present report.

No unique patient identifier: the dataset relied on participant names rather than a unique identifier; several records shared an identical first name, and in two instances also an identical age, which could not be resolved as either coincidence (common regional given names) or duplicate data entry.

Causality: as an observational case–control study, this design can identify associations but cannot establish that SARS-CoV-2 infection causes the haematological changes observed; reverse causation and unmeasured confounding (for example, by pre-eclampsia, gestational diabetes, or other pregnancy complications not captured in the dataset) cannot be excluded.

CONCLUSION

In this single-centre case–control study of third-trimester pregnant women, COVID-19-positive participants showed significantly higher total leucocyte counts, higher neutrophil percentage, lower lymphocyte percentage, higher neutrophil-to-lymphocyte ratio and more frequent CRP positivity than COVID-negative pregnant women, without significant differences in haemoglobin, platelet count, PT, APTT, INR, D-dimer, LDH or serum ferritin. These findings are consistent with a systemic inflammatory response associated with SARS-CoV-2 infection but do not establish causation and do not, on their own, support any change to routine antenatal laboratory practice. Placental pathological correlation could not be assessed in the present dataset and remains an important direction for further study.

Declarations

Ethics Approval and Consent to Participate

The study was submitted to and approved by the Institutional Ethics Committee of Shivamogga Institute of Medical Sciences (SIMS), Shivamogga, Karnataka, India. Written informed consent was obtained from all participants before their inclusion in the study.

Consent for Publication

Written informed consent was obtained from the participants for the use and publication of the study findings in an anonymized form.

Competing Interests

The authors declare that they have no competing interests.

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Data Availability

The data supporting the findings of this study are available from the corresponding author upon reasonable request, subject to appropriate ethical and institutional restrictions.

Authors' Contributions

All authors contributed to the conception and design of the study, data collection and/or analysis, interpretation of the findings, and preparation and critical revision of the manuscript. All authors approved the final version of the manuscript and agreed to be accountable for all aspects of the work.

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AI Use Disclosure

The authors declare that no generative artificial intelligence tools were used to generate or substantially modify the scientific content of this manuscript.

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