PERINATAL JOURNAL

Original Article

Perinatal Journal 2022;30(2):172–178

The effect of COVID-19 infection on hematological parameters and early pregnancy loss

Zeliha Atak, Sakine Rahimli Ocakoğlu, Özlem Uyanıklar, Emin Üstünyurt

Department of Obstetrics & Gynecology, Bursa City Hospital, Bursa

Abstract

Objective: Based on the fact that Coronavirus Disease 2019 (COVID-19) is associated with many hemocytometric changes, we aimed to investigate the effect of this underlying inflammatory process on the frequency of early pregnancy loss (EPL) in this clinical trial.

Methods: This is a retrospective cohort study. The patients with laboratory-confirmed COVID-19 infection before the 20 weeks of gestation were determined as the study group. Healthy pregnant women in their early pregnancy were determined as the control group. Hematological parameters of all patients included in the analysis were evaluated.

Results: A total of 176 pregnant women with confirmed COVID-19 infections were evaluated, of which 117 were included in the analysis. One hundred and seventeen healthy pregnant women were determined as the control group. There was no difference between the groups according to demographic characteristics. The median white blood cell (WBC) and lymphocyte levels were lower in patients with COVID-19 infection ($p<0.001$ and $p<0.001$, respectively). The value of platelet/lymphocyte ratio (PLR) was higher in the group with COVID-19 infection (160.95 vs. 132.42, $p<0.001$). It was also determined that the median plateletcrit level was lower in the group with COVID-19 infection ($p<0.001$). The rate of EPL in the COVID-19 infection group and control group was 14.2% and 9.4%, respectively ($p=0.220$).

Conclusion: COVID-19 infection presents with low lymphocyte count and plateletcrit values in pregnant women, and an increase in PLR rates in relation to the severity of the disease is observed. Although not statistically significant, COVID-19 infection was associated with increased EPL rates in our study.

Keywords: Early pregnancy loss, neutrophil/lymphocyte ratio, platelet/lymphocyte ratio, SARS-CoV-2 infection.

Introduction

Severe Acute Respiratory Syndrome Coronavirus-2 (SARS-CoV-2) infection, which mainly presents with respiratory system symptoms, can evolve into a multisystem organ failure and pregnant women are at a heightened risk.[1] Furthermore, pregnant women are at an increased risk of poor obstetrical outcomes.[2,3]

Studies have shown that there is an increase in the frequency of preterm birth, intrauterine fetal death and cesarean section in cases with Coronavirus disease 2019 (COVID-19) infection during pregnancy.[4–6] However, the effect of COVID-19 infection on the frequency of early pregnancy loss (EPL) is not yet apparent.[4] Studies in the literature evaluating the relationship between SARS-CoV-2 infection and EPL risk are mostly in the form of case reports and case series.[7]

The complete blood count is the first laboratory test used in the evaluation of infectious diseases. During the COVID-19 pandemic, the relationship of many hematological parameters with the severity of the disease has been studied.[8,9] Neutrophil-lymphocyte ratio (NLR), platelet-lymphocyte ratio (PLR), and mean platelet volume (MPV), which can be easily reached through routine hematological parameters, are indicators of inflammatory status that have also been studied in obstetric

Correspondence: Zeliha Atak, MD. Department of Obstetrics & Gynecology, Bursa City Hospital, 16110, Nilüfer, Bursa, Turkey.
e-mail: zeliha.atak@hotmail.com / **Received:** March 27, 2022; **Accepted:** May 19, 2022

How to cite this article: Atak Z, Rahimli Ocakoğlu S, Uyanıklar Ö, Üstünyurt E. The effect of COVID-19 infection on hematological parameters and early pregnancy loss. Perinat J 2022;30(2):172–178. doi:10.2399/prn.22.0302011

ORCID ID: Z. Atak 0000-0002-4876-0573; S. Rahimli Ocakoğlu 0000-0001-8159-9489; Ö. Uyanıklar 0000-0002-9800-256X; E. Üstünyurt 0000-0001-5602-6785

deomed

practice.[10] NLR in the first trimester, can aid in estimating the risk of certain complications of pregnancy.[11] For example, increased NLR was found to be associated with severe preeclampsia, gestational diabetes, gestational cholestasis, hyperemesis gravidarum, EPL and preterm labor.[12,13]

There are also studies investigating the relationship between the platelet indices and the risk of EPL.[14–16] In addition, studies have shown that low MPV, lymphopenia, and high PLR are associated with EPL.[13,15]

Although there are many studies in the literature on the course of COVID-19 infection in pregnant women, there is a need for good quality studies to illuminate its relationship with early pregnancy complications. Because COVID-19 infection is a process that occurs with changes in hematological parameters which support inflammation, we aimed to investigate the effect of this underlying inflammatory process on the rate of EPL. We hypothesized that increased indices of inflammation in COVID-19 are associated with an increased risk of EPL.

To the best of our knowledge, this is the first study from our country to evaluate the risk of EPL in pregnant women with COVID-19 infection under 20 weeks of gestation, along with associated hematological parameters.

Methods

This is a retrospective cohort study. Pregnant women under 20 weeks of gestation who were evaluated for COVID-19 infection at the Gynecology and Obstetrics Department of Bursa City Hospital between December 2020 and June 2021 were included in the study. The study was approved by the Clinical Research Ethics Committee of Bursa City Hospital (Approval number: 2021-11/1). The patients with laboratory confirmed SARS-CoV-2 infection before 20 weeks of gestation were determined as the study group (COVID +), and pregnant women who did not have a history of COVID-19 infection before 20 weeks of gestation as control group (COVID -). The data from 117 patients in both groups were included in the analysis. The patients in both groups were followed up through the hospital database throughout the pregnancy. The body mass index, obstetrical history, and hematological parameters of the patients were examined. Both groups were comparable with respect to demographic parameters. The laboratory diagnosis of infection was made by real-time polymerase chain reaction (RT-PCR) test. The blood samples were collected at the time of admission. The patients whose hematological parameters could be accessed through the hospital database were included in the study. The patients who did not have blood tests due to mild symptoms were not included in the study. Neutrophil/lymphocyte and platelet/lymphocyte ratios were calculated for all patients included in the analysis. The control group consists of patients with matching gestational age. The blood samples of the patients in the control group were also taken at similar weeks of gestation. The patients with severe infection symptoms were hospitalized and determined as inpatient group. The patients who did not need inpatient treatment were included as the outpatient group. In the subgroup analysis, the comparisons were made as the control group, the inpatient group and the outpatient group. The pregnancies that ended with miscarriage before the 20 weeks of gestation were considered as early pregnancy loss. After RT-PCR positivity patients who had EPL at the time of admission to the hospital or during hospitalization were considered as EPL associated with COVID-19 infection.

The Shapiro–Wilk test was used to assess whether the variables followed a normal distribution or not. Variables were reported as mean±standard deviation and median (minimum–maximum) values. According to the normality test results, independent samples t-test, Mann-Whitney U-test and Kruskal-Wallis test were used to compare the groups.

Comparison of EPL rates between COVID-19 infected and non-infected groups was made using the chi-square test. The relationships between age and hematological measurements were examined by correlation analysis, for which the Spearman's correlation coefficient was calculated. Statistical analyses were performed by using SPSS version 23.0 (SPSS Inc., Chicago, IL, USA). A p-value of 5% was considered statistically significant for all statistical comparisons.

Results

A total of 176 pregnant women who were confirmed to have COVID-19 infection by RT-PCR test for SARS-CoV-2 on combined oropharyngeal and nasopharyngeal swabs were included in the study. We excluded 59

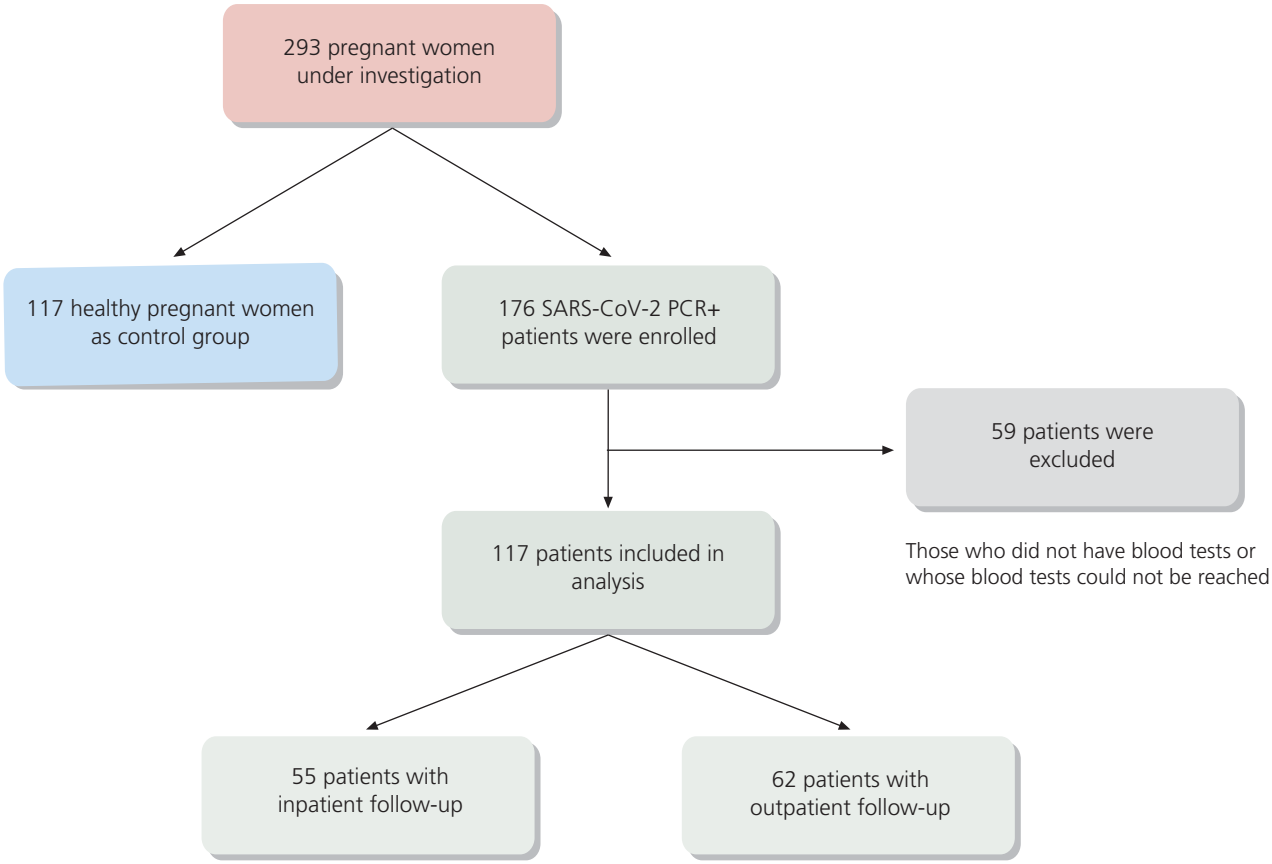

Fig. 1. Flowchart of patient selection.

patients who did not have blood tests or whose blood tests could not be reached through the hospital database. One hundred and seventeen healthy pregnant women were determined as the control group (**Fig. 1**). There was no difference in the demographic characteristics of the patients between the groups (**Table 1**).

The median white blood cell (WBC) level was found to be lower in the group with COVID-19 infection (6570 vs. 8920, p<0.001). It was also determined that the lymphocyte level was lower in patients with COVID-19 infection (1360 vs. 2010, p<0.001). According to the NLR ratio, there was no difference between the groups

Table 1. Demographic characteristics of the patients.

	COVID (+) (n=117)	COVID (-) (n=117)	p-value*
Age (years)	28 (16–40)	27 (18–42)	0.786
BMI (kg/m²)	26.03 (17.36–44.77)	26.30 (18.08–39.51)	0.782
Gestational age at admission	11(5–19)	9 (5–18)	0.097
Gravida	2 (1–6) (2.36±1.18)	2 (1–6) (2.08±1.02)	0.075
Parity	1 (0–4)	1 (0–3)	0.172
Abortion history	0 (0–3)	0 (0–2)	0.124

Data were reported as mean ± st. deviation and median (minimum–maximum). *Mann-Whitney U test. **BMI:** Body mass index.

(p=0.554). However, the value of PLR differed between the groups, and it was determined that it was higher in the group with COVID-19 infection (160.95 vs. 132.42, p<0.001). While there was no difference between the groups according to MPV and PDW measurements (p=0.826 and p=0.914, respectively), it was determined that the median plateletcrit (PCT) level was lower in the group with COVID-19 infection (0.23 and 0.27, p<0.001) (**Table 2**).

As a result of the comparisons made between patients who had EPL and had a COVID-19 infection, and those whose pregnancy ended with EPL but had no COVID-19 infection, the mean WBC level was lower in patients with COVID-19 group (6912.80 vs. 8603.63, p=0.046), median lymphocyte level was lower in patients with COVID-19 (1350). vs. 2150, p<0.001), median PLR was higher in COVID-19 infected patients (160.95 vs. 134.36, p=0.038) and median PCT level was lower in COVID-19 patients (0.23 vs. 0.29, p=0.004). There was no difference between the groups in terms of NLR, MPV and PDW levels (p>0.05) (**Table 2**).

The subgroup analysis determined that the median lymphocyte levels of the outpatient and inpatient groups were lower than the patients who did not have COVID-19 infection (p<0.001 and p<0.001, respectively). It was determined that the median PLR values of the outpatient and inpatient groups were higher than the patients who did not have COVID-19 infection (p=0.008 and p<0.001, respectively). Again, in the subgroup analysis, it was determined that the median PCT levels of the outpatient and inpatient groups were lower than the patients who did not have COVID-19 infection (p=0.001 and p<0.001, respectively). On the other hand, there was no difference in terms of NLR ratio, MPV and PDW levels between the groups (p>0.05) (**Table 3**).

It was determined that there was no relationship between age and hematological measurements in patient groups with and without COVID-19 infection. While EPL was observed in 14.20% (n=25) of 176 patients who had COVID-19 infection, this rate was determined as 9.40% (n=11) in 117 patients who did

Table 2. The effect of COVID-19 infection on hematological parameters in all cases (n=234) and in patients whose pregnancy ended with early pregnancy loss (n=36).

	Total study group		
n=234	**COVID (+) (n=117)**	**COVID (-) (n=117)**	**p-value**
WBC	6570 (2470–13.710)	8920 (5040–14.650)	**<0.001***
Lymphocyte	1360 (220–4170)	2010 (640–4080)	**<0.001***
NLR	3.17 (0.44–28.73)	3.10 (0.98–11.61)	0.554*
PLR	160.95 (73.62–1068.18)	132.42 (69.77–339.06)	**<0.001***
MPV	10.20 (7.5–13.6)	10.20 (8.1–13.3)	0.826*
PDW	11.40 (8.4–22.4)	11.50 (8.2–17.3)	0.914*
PCT	0.23 (0.03–0.38)	0.27 (0.16–0.49)	**<0.001***
	Early pregnancy loss group		
n=36	**COVID (+) (n=25)**	**COVID (-) (n=11)**	**p-value**
WBC	6912.80±2202.33	8603.64±2373.38	**0.046†**
Lymphocyte	1350 (300–4170)	2150 (1470–2830)	**<0.001***
NLR	4.07 (1.32–28.73)	2.17 (1.74–4.35)	0.054*
PLR	160.95 (73.62–670)	134.36 (87.5–214.97)	**0.038***
MPV	10.2 (9.2–13.6)	11 (9.5–11.4)	0.068*
PDW	11.3 (9.2–22.4)	12.9 (10.1–16.4)	0.068*
PCT	0.23 (0.03–0.38)	0.29 (0.22–0.43)	**0.004***

Data were reported as median (minimum–maximum). *Mann-Whitney U test, †Independent sample t-test. **MPV:** mean platelet volume; **NLR:** neutrophil-to-lymphocyte ratio; **PCT:** plateletcrit; **PDW:** platelet distribution width; **PLR:** platelet-lymphocyte ratio; **WBC:** white blood cell.

Table 3. Relationship between disease severity and hematological parameters.

	COVID (-) (n=117)	COVID (+) Outpatient (n=62)	COVID (+) Inpatient (n=55)	p-value*
WBC	8920 (5040–14.650)	6640 (2470–11.950)	6140 (2950–13.710)	<0.001
Lymphocyte	2010 (640–4080)	1520 (220–3210)	1260 (300–4170)	<0.001
NLR	3.10 (0.98–11.61)	2.98 (0.69–26.84)	3.42 (0.44–28.73)	0.392
PLR	132.42 (69.77–339.06)	153.77 (79.66–1068.18)	176.55 (73.62–709.09)	<0.001
MPV	10.20 (8.1–13.3)	10.3 (8.8–13.6)	10.1 (7.5–12.5)	0.570
PDW	11.50 (8.2–17.3)	11.35 (8.9–22.4)	11.6 8.4–17.1)	0.991
PCT	0.27 (0.16–0.49)	0.24 (0.03–0.37)	0.23 (0.1–0.38)	<0.001

Data were reported as median (minimum–maximum). *Kruskal-Wallis test. **MPV:** mean platelet volume; **NLR:** neutrophil-to-lymphocyte ratio; **PCT:** plateletcrit; **PDW:** platelet distribution width; **PLR:** platelet-lymphocyte ratio; **WBC:** white blood cell.

not have COVID-19 infection. No statistically significant difference was observed between the groups regarding EPL rates (p=0.220).

Discussion

With the identification of the first cases in December 2019, the COVID-19 pandemic has affected the whole world as the first case in Turkey was announced on March 11, 2020.[17] The effect of this infection on pregnant women contains many uncertainties.[18] We predicted that there might be an increase in the risk of EPL as a result of the inflammatory process caused by SARS-Cov-2 infection. There are case reports in the literature reporting pregnancy loss before the 20 weeks of gestation during COVID-19 infection.[4,7,19,20] However, studies on a large patient population in early weeks of gestation are limited.[21] The studies conducted mostly cover the 3rd trimester pregnant women. Unlike other studies in the literature, our study only included patients at an early gestation.

Hassanipour et al. reported a significant increase in neutrophil ratio in patients infected with SARS-Cov-2.[22] It has also been reported in many studies that increased NLR during SARS-Cov-2 infection is associated with poor prognosis.[23–26] In our study, although there was a slight increase in NLR rates in the inpatient group compared to the control group, we observed no significant increase in this parameter. This increase was more pronounced in the group of patients with COVID-19 infection whose pregnancy ended with EPL, even if the difference did not reach a statistically significant level.

Erol Koç et al. evaluated hematological parameters and pregnancy outcomes in pregnant women with COVID-19 infection. While there was no difference between obstetric and neonatal outcomes, NLR was found to be high, and PCT was found to be low in COVID-19 infection group.[27] In our study, there was no difference in NLR values between the groups, but similarly, PCT values were low in the COVID (+) patient group.

It has been shown that the lymphocyte count and NLR ratio at the time of admission is related to the severity of the disease.[28] While no difference was observed in NLR rates in our study group, it was observed that lymphopenia became more pronounced with disease severity. We observed that lymphopenia is a prominent laboratory finding, especially in the inpatient group.

As in a very recently published study, there was no significant difference in NLR rates in the COVID-19 group as in our study, but PLR was found to be significantly higher in the COVID-19 infection group.[29] In addition, we observed that the PLR value increased with the severity of the infection. This increase was also found in patients who had EPL.

In a multicenter study, the frequency of EPL in the patient group diagnosed with COVID-19 was reported 2.3%.[30] Whereas in a prospective study, the frequency of spontaneous abortion was reported 6.1%.[31] With the progression of the pandemic, a recent review reported the overall miscarriage rate in pregnant women with COVID-19 15.3%. Based on the studies in the literature, it was stated that COVID-19 infection

does not increase the risk of EPL.[32,33] In our study, the EPL rate was 14.2% in the COVID-19 infection group, while it was 9.4% in the control group.

Strengths of our study: Mostly late 2nd trimester and 3rd trimester pregnant women were included in the studies evaluating the effect of COVID-19 infection on maternal and neonatal outcomes. The current study differs from previous studies in the literature by evaluating the impact of COVID-19 infection directly on the risk of EPL.

The main limitations is related to the lack of correlation with the clinical context. Regarding the severity of the disease, there was no hospital record of the symptoms and vital signs of the patients who were admitted to the hospital due to COVID-19 infection. In addition, the number of patients in our study was not large enough to make a general conclusion about the impact of COVID-19 infection on the rate of EPL.

Conclusion

Increased PLR, lymphopenia and low PCT values were observed in pregnant women who had COVID-19 infection under 20 weeks of gestation. We have also demonstrated in this study that COVID-19 infection observed in early pregnancy causes a slight increase in EPL rates, though this did not reach a statistical significance, likely due to the small sample size. The causes of the EPL is difficult to ascertain before COVID-19. Further, larger studies are needed to determine the relationship between COVID-19 and EPL.

Funding: This work did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Compliance with Ethical Standards: The authors stated that the standards regarding research and publication ethics, the Personal Data Protection Law and the copyright regulations applicable to intellectual and artistic works are complied with and there is no conflict of interest.

References

1. CDC. Investigating the impact of COVID-19 during pregnancy. [Internet] Available at: https://www.cdc.gov/coronavirus/2019-ncov/cases-updates/special-populations/pregnancy-data-on-covid-19/what-cdc-is-doing.html (accessed May 17, 2022).
2. Maleki Dana P, Kolahdooz F, Sadoughi F, Moazzami B, Chaichian S, Asemi Z. COVID-19 and pregnancy: a review of current knowledge. Infez Med 2020;28(Suppl 1):46–51. [PubMed]
3. Chi J, Gong W, Gao Q. Clinical characteristics and outcomes of pregnant women with COVID-19 and the risk of vertical transmission: a systematic review. Arch Gynecol Obstet 2021; 303:337–45. [PubMed] [CrossRef]
4. Wong TC, Lee ZY, Sia TLL, Chang AKW, Chua HH. Miscarriage risk in COVID-19 infection. SN Compr Clin Med 2020;2:1449–52. [PubMed] [CrossRef]
5. WAPM (World Association of Perinatal Medicine) Working Group on COVID-19. Maternal and perinatal outcomes of pregnant women with SARS-CoV-2 infection. Ultrasound Obstet Gynecol 2021;57:232–41. [PubMed] [CrossRef]
6. Khalil A, Blakeway H, Samara A, O'Brien P. COVID-19 and stillbirth: direct vs indirect effect of the pandemic. Ultrasound Obstet Gynecol 2022;59:288–95. [PubMed] [CrossRef]
7. Baud D, Greub G, Favre G, Gengler C, Jaton K, Dubruc E, et al. Second-trimester miscarriage in a pregnant woman with SARS-CoV-2 infection. JAMA 2020;323:2198–200. [PubMed] [CrossRef]
8. Khartabil TA, Russcher H, van der Ven A, de Rijke YB. A summary of the diagnostic and prognostic value of hemocytometry markers in COVID-19 patients. Crit Rev Clin Lab Sci 2020;57: 415–31. [PubMed] [CrossRef]
9. Yang AP, Liu JP, Tao WQ, Li HM. The diagnostic and predictive role of NLR, d-NLR and PLR in COVID-19 patients. Int Immunopharmacol 2020;84:106504. [PubMed] [CrossRef]
10. Liu Y, Du X, Chen J, Jin Y, Peng L, Wang HHX, et al. Neutrophil-to-lymphocyte ratio as an independent risk factor for mortality in hospitalized patients with COVID-19. J Infect 2020;81:e6–e12. [PubMed] [CrossRef]
11. Christoforaki V, Zafeiridiou Z, Daskalakis G, Katassos T, Siristatidis C. First trimester neutrophil to lymphocyte ratio (NLR) and pregnancy outcome. J Obstet Gynaecol 2020;40: 59–64. [PubMed] [CrossRef]
12. Biyik I, Albayrak M, Keskin F. Platelet to lymphocyte ratio and neutrophil to lymphocyte ratio in missed abortion. Rev Bras Ginecol Obstet 2020;42:235–9. [PubMed] [CrossRef]
13. Oğlak SC, Aydin MF. Are neutrophil to lymphocyte ratio and platelet to lymphocyte ratio clinically useful for the prediction of early pregnancy loss? Ginekol Pol 2020;91:524–7. [PubMed] [CrossRef]
14. Akin MN, Kasap B, Yuvaci HU, Turhan N. Association between platelet indices and first trimester miscarriage. Blood Coagul Fibrinolysis 2016;27:526–30. [PubMed] [CrossRef]
15. Ata N, Kulhan M, Kulhan NG, Turkler C. Can neutrophil-lymphocyte and platelet-lymphocyte ratios predict threatened abortion and early pregnancy loss? Ginekol Pol 2020;91:210–5. [PubMed] [CrossRef]
16. Aynıoğlu O, Isık H, Sahbaz A, Harma MI, Isık M, Kokturk F. Can plateletcrit be a marker for recurrent pregnancy loss? Clin Appl Thromb Hemost 2016;22:447–52. [PubMed] [CrossRef]
17. Ministry of Health, Republic of Turkey (MoH-TR). COVID-19 web page of the Republic of Turkey, Ministry of Health. [Internet] Available at: https://covid19.saglik.gov.tr (accessed May 17, 2022).
18. Wastnedge, EAN, Reynolds RM, van Boeckel SR, Stock SJ, Denison FC, Maybin JA, et al. Pregnancy and COVID-19. Physiol Rev 2021;101:303–18. [PubMed] [CrossRef]

19. Hachem R, Markou GA, Veluppillai C, Poncelet C. Late miscarriage as a presenting manifestation of COVID-19. Eur J Obstet Gynecol Reprod Biol 2020;252:614. [PubMed] [CrossRef]
20. Rana MS, Usman M, Alam MM, Khalid A, Ikram A, Salman M, et al. First trimester miscarriage in a pregnant woman infected with COVID-19 in Pakistan. J Infect 2021;82:e27–e28. [PubMed] [CrossRef]
21. Yapar Eyi EG, Moraloglu Tekin O, Buglagil A, Sahin D, Yucel A, Tanacan A, et al. Perinatology clinic in the coronavirus disease-2019 pandemic: what harms, often teaches. J Matern Fetal Neonatal Med 2021;34:3591–600. [PubMed] [CrossRef]
22. Hassanipour S, Faradonbeh SB, Momeni K, Heidarifard Z, Khosousi M-J, Khosousi L, et al. A systematic review and meta-analysis of pregnancy and COVID-19: signs and symptoms, laboratory tests, and perinatal outcomes. Int J Reprod Biomed 2020;18:1005–18. [PubMed] [CrossRef]
23. Liu J, Liu Y, Xiang P, Pu L, Xiong H, Li C, et al. Neutrophil-to-lymphocyte ratio predicts critical illness patients with 2019 coronavirus disease in the early stage. J Transl Med 2020;18:206. [PubMed] [CrossRef]
24. Şan İ, Gemcioğlu E, Davutoğlu M, Çatalbaş R, Karabuğa B, Kaptan E, et al. Which hematological markers have predictive value as early indicators of severe COVID-19 cases in the emergency department? Turk J Med Sci 2021;51:2810–21. [PubMed] [CrossRef]
25. Ponti G, Maccaferri M, Ruini C, Tomasi A, Ozben T. Biomarkers associated with COVID-19 disease progression. Crit Rev Clin Lab Sci 2020;57:389–99. [PubMed] [CrossRef]
26. Lin S, Mao W, Zou Q, Lu S, Zheng S. Associations between hematological parameters and disease severity in patients with SARS-CoV-2 infection. J Clin Lab Anal 2021;35:e23604. [PubMed] [CrossRef]
27. Erol Koç EM, Bedir Fındık R, Akkaya H, Karadağ I, Özden Tokalıoğlu E, Moraloğlu Tekin Ö. Comparison of hematological parameters and perinatal outcomes between COVID-19 pregnancies and healthy pregnancy cohort. J Perinat Med 2021;49:141–7. [PubMed] [CrossRef]
28. Lasser DM, Chervenak J, Moore RM, Li T, Knight C, Teo HO, et al. Severity of COVID-19 respiratory complications during pregnancy are associated with degree of lymphopenia and neutrophil to lymphocyte ratio on presentation: a multicenter cohort study. Am J Perinatol 2021;38:1236–43. [PubMed] [CrossRef]
29. Carranza Lira S, Garcia Espinosa M. Differences in the neutrophil/lymphocyte ratio and the platelet/lymphocyte ratio in pregnant women with and without COVID-19. Int J Gynaecol Obstet 2022;157:296–302. [PubMed] [CrossRef]
30. Di Mascio D, Sen C, Saccone G, Galindo A, Grünebaum A, Yoshimatsu J, et al. Risk factors associated with adverse fetal outcomes in pregnancies affected by Coronavirus disease 2019 (COVID-19): a secondary analysis of the WAPM study on COVID-19. J Perinat Med 2020;48:950–8. [PubMed] [CrossRef]
31. Shmakov RG, Prikhodko A, Polushkina E, Shmakova E, Pyregov A, Bychenko V, et al. Clinical course of novel COVID-19 infection in pregnant women. J Matern Fetal Neonatal Med 2020;29:1–7. doi:10.1080/14767058.2020.1850683 [PubMed] [CrossRef]
32. Cosma S, Carosso AR, Cusato J, Borella F, Carosso M, Bovetti M, et al. Coronavirus disease 2019 and first-trimester spontaneous abortion: a case-control study of 225 pregnant patients. Am J Obstet Gynecol 2021;224:391.e1–391.e7. [PubMed] [CrossRef]
33. Cavalcante MB, de Melo Bezerra Cavalcante CT, Cavalcante ANM, Sarno M, Barinin R, Kwak-Kim J. COVID-19 and miscarriage: From immunopathological mechanisms to actual clinical evidence. J Reprod Immunol 2021;148:103382. [PubMed] [CrossRef]