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ORIGINAL ARTICLE

Evaluation of Radiological Findings of Pregnant Women with COVID-19

Hilal Gülsüm Turan Özsoy[1], Gültekin Adanaş Aydın[2], Serhat Ünal[2]

[1]Department of Radiology, Bursa City Hospital, Bursa, Turkiye
[2]Department of Obstetrics and Gynecology, Bursa City Hospital, Bursa, Turkiye

Abstract

Introduction: This study aims to evaluate the radiological findings of pregnant women with COVID-19 pneumonia.

Methods: A total of 192 pregnant women diagnosed with COVID-19 by performing real-time reverse transcriptase-polymerase chain reaction test (RT-PCR) were studied retrospectively. Chest X-rays and thoracic CT findings were defined by dividing patients into three groups according to the time of diagnosis: <12 weeks of gestation (first trimester, n=15), 12-24 weeks of gestation (second trimester, n=33), and >24 weeks of gestation (third trimester, n=144). Only 98 patients who underwent chest X-ray and computed tomography (CT) were included in the study. Data including affected lung side, number of involved lobes, number of lesions, lesion density/opacity, and parenchymal infection pattern were evaluated.

Results: Twenty-five patients were asymptomatic at the time of admission, and the most common symptom was dry cough in 103 patients. The median D-dimer level was the lowest in the first trimester group (<12 weeks) and the highest in the third trimester group (>24 weeks). The mean white blood cell count was significantly higher in the third trimester group (>24 weeks) than in the first trimester group (<12 weeks) (p=0.036). Ninety-eight patients underwent radiological imaging studies. Findings suggestive of COVID-19 pneumonia were found in 59 (65%) out of 90 patients by means of chest radiography and in 21 (87.5%) out of 24 patients by performing thorax tomography. The most common findings were bilateral and multilobar lung involvement, patchy involvement, and ground-glass opacities (GGOs).

Discussion and Conclusion: This study's results show that pregnant women with COVID-19 have similar radiological findings to non-pregnant COVID-19 patients, and the most common findings are bilateral and multilobar involvement. Furthermore, pregnant patients can be admitted with lower GGO (lesion in ground glass density) rates and higher consolidation rates compared to the general population.

Keywords: COVID-19; computed tomography; pregnancy.

In December 2019, the government agencies of China notified the World Health Organization (WHO) of the presence of a highly contagious pneumonia outbreak with an unknown origin arising in Wuhan, Hubei Province[1]. In the middle of February, the WHO named this new contagious disease coronavirus disease 2019 (COVID-19) [1]. The virus, caused by the severe acute respiratory syndrome-coronavirus 2 (SARS-CoV-2), has spread rapidly around the world, resulting in a devastating outbreak, and the WHO declared it a global pandemic on March 8th, 2020[2].

Correspondence: Gültekin Adanaş Aydın, M.D. Department of Obstetrics and Gynecology, Bursa City Hospital, Bursa, Turkiye
Phone: +90 544 860 82 82 **E-mail:** gadanas@gmail.com
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About 80% of the cases are asymptomatic or have mild symptoms, and the most common symptoms include cough, shortness of breath, malaise, sore throat, headache, chest pain, diarrhea, vomiting, and anosmia[3]. Extrapulmonary symptoms include renal, gastrointestinal, hepatic, cardiac, neurological, and hematological manifestations[4].

Pregnant COVID-19 patients are typically young and healthy individuals. However, pregnant women are known to be prone to respiratory tract infections due to hormonal and immune system alterations and anatomical and physiological changes during pregnancy[5]. Immune system alterations during pregnancy make pregnant women more vulnerable to infections, particularly viral infections that may cause more severe symptoms[6]. Previous studies have reported an association between SARS/Middle East respiratory syndrome (MERS) infections and severe maternal conditions, maternal death, and spontaneous miscarriage[7]. These findings imply that pregnant women constitute a unique patient population.

The standard reference test used in the diagnosis of COVID-19 is real-time reverse transcriptase polymerase chain reaction (RT-PCR). However, imaging modalities such as thoracic computed tomography (CT) and chest X-ray also play an important role in the diagnosis and assessment of pregnant patients suspected of having COVID-19 due to technical limitations and relatively high rates of false-negative results in RT-PCR[8]. It has been shown that thoracic CT has higher sensitivity than other methods in diagnosing COVID-19 pneumonia[9].

The risks to the fetus associated with exposure to ionizing radiation during pregnancy appear as a limitation for the use of radiological methods in the diagnosis and treatment of pregnant women, and the diagnostic work-up is more challenging in these patients[10]. Therefore, pregnant women constitute a particular patient group requiring special attention in the diagnosis and treatment of COVID-19. While guidelines usually recommend avoiding ionizing radiation during pregnancy, appropriate protection and the use of low-dose protocols may allow relatively safe use of radiological methods, if indicated[11].

Before the widespread use of RT-PCR test kits, some centers used thoracic CT scans to confirm the diagnosis and monitor disease progression[9,12,13]. The most common CT findings of COVID-19 in the general patient population include peripheral and posterior multifocal or patchy ground-glass opacities (GGOs) with or without superimposed consolidations[13,14]. Currently, there is a paucity of robust data in the literature regarding radiological features of COVID-19 pneumonia in pregnant women. In the present study, we, therefore, aimed to evaluate the radiological findings of pregnant women with COVID-19 pneumonia and contribute to the literature regarding this unique patient population.

Materials and Methods

Study Design and Study Population

This single-center, retrospective study was conducted in the radiology clinic of a tertiary care center between April 1st, 2020, and December 1st, 2020. A total of 192 pregnant women who were admitted to the Department of Infectious Diseases during the study period were screened. This study was carried out by examining data collected from 192 pregnant patients diagnosed with COVID-19 by using the real-time reverse transcriptase-polymerase chain reaction (RT-PCR) test. Out of 192 patients, 98 who underwent either chest radiography or thorax tomography were included in the study. The diagnosis of COVID-19 was made according to the WHO temporary case definition[15]. The definitive diagnosis was established by RT-PCR testing of the combined nasopharyngeal/oropharyngeal swabs. Written informed consent was obtained from each patient. The study protocol was approved by the institutional Ethics Committee (No: 2021-10/7). The study was conducted in accordance with the principles of the Declaration of Helsinki.

Epidemiological and demographic characteristics of the patients, clinical and laboratory parameters, and diagnostic radiological study results such as chest X-rays and thoracic CT scans were retrieved retrospectively from the hospital database. Thoracic CT scans and chest X-rays were evaluated on the Picture Archiving and Communication System (PACS). Chest X-rays and thoracic CT findings were defined by dividing the patients into three groups according to the time of diagnosis: <12 weeks of gestation (first trimester, n=15), 12-24 weeks of gestation (second trimester, n=33), and >24 weeks of gestation (third trimester, n=144).

Imaging Protocol

Advanced radiological imaging studies (thoracic CT) were used in the presence of at least two signs or symptoms, such as fever (body temperature above 38.3°C), increased respiratory rate (≥22 bpm), decreased oxygen saturation (SpO2 ≤ 93%), and severe dyspnea.

The imaging method was selected (chest X-ray and/or CT) depending on the individual performances of diagnostic

Table 1. Numerical Data of Patients According to Gestational Age

	Week	N	Mean	SD	Min	Max	Percentiles			P*
							25	Median**	75	
Gestational Age (Week)	<12	15	28.47	6.21	19.00	40.00	23.00	28.00	35.00	0.908
	12-24	33	28.61	4.70	20.00	38.00	25.00	28.00	32.50	
	>24	144	29.04	5.72	17.00	44.00	25.00	29.00	32.75	
BMI (kg/m^2)	<12	13	27.77	5.99	19.14	37.66	23.44	25.71	33.75	0.605
	12-24	30	28.86	4.48	22.15	39.45	25.30	27.93	32.82	
	>24	133	29.06	4.84	19.36	46.87	25.91	28.52	31.25	
Gravida	<12	14	2.43	.85	1.00	4.0	2.0	2.5	3.0	
	12-24	32	2.75	1.34	1.00	6.0	2.0	2.5	4.0	
	>24	142	2.29	1.40	1.00	9.0	1.00	2.0	3.0	
Parity	<12	14	1.00	.68	0	2.0	.75	1.0	1.25	
	12-24	32	1.47	1.16	0	4.0	1.0	1.0	2.0	
	>24	142	1.06	1.17	0	6.0	0	1.0	2.0	
Abortion	<12	14	.43	.85	0	3.0	0	0	1.0	
	12-24	32	.28	.58	0	2.0	0	0	0	
	>24	142	.22	.60	0	3.0	0	0	0	
Body temperature (°C)	<12	15	37.04	.96	36.2	39.5	36.4	36.8	37.1	0.351
	12-24	33	36.68	.61	36.0	38.9	36.3	36.5	36.90	
	>24	138	36.86	.79	36.0	40.0	36.3	36.6	37.1	
WBC (10^3/µL)	<12	15	6.85	3.33	3.17	15.11	4.52	5.78^a	7.86	0.036
	12-24	32	7.51	2.90	3.36	16.73	5.61	6.65^{ab}	8.82	
	>24	140	8.01	2.55	3.02	17.73	6.26	7.70^b	9.42	
Hb (g/dL)	<12	15	11.64	2.18	6.50	14.0	11.70	12.1^a	13.1	0.020
	12-24	32	10.79	1.21	8.60	12.7	9.80	10.7^b	11.88	
	>24	140	11.29	1.39	7.80	15.2	10.33	11.3^{ab}	12.2	
Platelet count (10^3/µL)	<12	15	222.60	81.73	122.0	379.0	172.0	180.0	275.0	0.552
	12-24	31	211.74	38.35	142.0	284.0	185.0	216.00	242.0	
	>24	140	208.61	68.27	103.0	601.0	163.25	202.0	240.7	
Lymphocyte count (10^3/µL)	<12	15	1.34	.68	.58	3.14	.74	1.24	1.63	0.124
	12-24	32	1.67	.72	.64	3.35	1.09	1.53	2.11	
	>24	140	1.40	.61	.40	3.35	.94	1.26	1.73	
AST (IU/L)	<12	14	24.18	13.23	10.0	52.0	14.65	18.0	34.75	0.433
	12-24	31	21.11	16.75	9.7	104.0	14.00	17.0	20.0	
	>24	138	24.85	31.92	7.0	325.0	15.00	19.0	24.0	
ALT (IU/L)	<12	14	23.43	17.05	8.0	68.0	9.75	18.0	33.25	0.371
	12-24	32	19.31	18.75	5.0	103.0	10.0	13.50	20.0	
	>24	138	20.08	28.30	5.0	233.0	10.0	13.0	18.0	
LDH (IU/L)	<12	11	229.45	138.5	107.0	603.0	147.0	191.0	250.0	0.167
	12-24	21	176.86	47.47	123.0	320.0	145.00	172.0	194.5	
	>24	94	195.0	50.04	114.0	366.0	164.75	186.5	209.2	
CRP (mg/L)	<12	11	12.65	16.14	.60	58.9	3.50	9.4	15.5	0.284
	12-24	31	22.54	24.50	1.10	112.0	6.80	14.4	29.1	
	>24	129	23.84	27.58	.70	150.4	6.05	12.8	31.65	
Ferritin (10^3/µL)	<12	12	50.83	40.14	5.31	120.0	15.23	34.04	92.22	0.952
	12-24	29	50.12	44.70	6.24	155.8	14.30	26.80	77.90	
	>24	125	58.74	76.64	5.70	443.0	18.0	30.45	63.75	
Procalcitonin (10^3/µL)	<12	10	.12	.15	.03	.54	.04	.08^a	.13	0.008
	12-24	23	.05	.03	.02	.12	.03	.04^b	.06	
	>24	99	.09	.10	.01	.65	.05	.06^a	.10	
D-dimer (ugFEU/mL)	<12	13	1.13	2.13	.20	7.75	.22	.30^a	.72	<0.001
	12-24	31	1.10	.97	.26	4.66	.53	.83^b	1.26	
	>24	127	1.48	1.04	.21	5.70	.82	1.14^c	1.83	

Table 1. CONT.

	Week	N	Mean	SD	Min	Max	Percentiles			P*
							25	Median**	75	
PT (sec)	<12	14	8.87	.71	7.40	10.40	8.54	8.87[c]	9.07	<0.001
	12-24	26	8.17	.33	7.68	8.94	7.99	8.13[b]	8.38	
	>24	117	7.95	.41	7.07	9.39	7.67	7.92[a]	8.23	
APTT (sec)	<12	14	29.32	4.38	23.30	41.00	26.08	28.95	30.9	0.065
	12-24	26	28.33	3.95	18.20	35.50	25.35	28.30	30.78	
	>24	116	30.57	4.46	22.10	41.50	27.63	30.05	33.75	
INR	<12	14	.95	.10	.80	1.14	.90	.97[c]	.99	0.001
	12-24	26	.91	.03	.86	1.00	.89	.91[b]	.93	

*Kruskal-Wallis test and Dunn post-hoc test; **Superscript letters represent significant differences. There is a significant difference between the weeks with different superscript letters. BMI: body mass index; WBC: White blood cell; Hb: hemoglobin; AST: aspartate amino transferase; ALT: alanine amino transferase; LDH: lactate dehydrogenase; CRP: C-reactive protein; PT: prothrombin time; APTT: activated partial thromboplastin time; INR: internationl normalizedratio.

tests, gestational week (trimester), and clinical condition of the patient. Chest X-ray was performed using a digital X-ray device (Siemens, Fusion Max, X-ray setting: 75-110 kVp, 4-8 mAs, table detector 43 cm x 35 cm, stand detector size 43x43 cm). The radiation dose did not exceed 0.07 mSv to acquire high-quality images.

In all patients, a low-dose image acquisition protocol was followed while acquiring CT scans of the thorax without contrast enhancement. Follow-up imaging studies were performed in the presence of clinical progression, secondary cardiopulmonary diseases, bacterial superinfection, and suspected pulmonary embolism. The images were acquired using the Somatom perspective scanner (Siemens Healthineers, Germany) using a slice thickness of 5 mm, tube potential of 80 kV, and a reference current of 50 mAs. The noise index using an automated milliampere technology (20 to 350 mA) was 80 kV tube voltage. The display field of view was 37.5x37.5 cm, and the window width/level was 50-350 HU for the lung and -600 to 1200 HU for the mediastinum. The images were acquired in axial, coronal, and sagittal planes. The patients were placed in the supine position and the images were acquired using the breath-hold technique at full inspiration without contrast medium injection. Thoracic CT scans and chest X-rays were evaluated by a single radiologist with 12 years of experience in thoracic radiology who was blinded to the initial radiology reports.

Assessment and Definitions

Variables used in the detailed analysis and evaluation of the lesions defined on thoracic CT scans and chest X-rays were as follows: the affected lung side (right, left, bilateral), number of involved lobes (upper lobe of right lung, middle lobe of right lung, lower lobe of right lung, lingular segment of left lobe, lower lobe of left lung), number of lesions (single, multiple), the lung field involved (peripheral, central, mixed), lesion density/opacity, parenchymal infection pattern (nodular, patchy, coalescent areas with ground-glass opacities [GGO], focal, segmental-lobar consolidation, peribronchial thickening, crazy-paving stone pattern), and additional findings (marked interstitium, marked vascularization within the lesion, halo sign, reversed halo sign, pleural effusion, lymphadenopathy [LAP]). The distribution of lung lesions was defined as follows: peripheral, outer one-third of the lung; central, inner two-thirds of the lung; and mixed, central and peripheral involvement in the presence of mixed involvement.

Statistical Analysis

Statistical analysis was performed using SPSS version 23.0 software (IBM Corp., Armonk, NY, USA). Descriptive data were expressed as mean±standard deviation (SD), median (min-max), or number and frequency, where applicable. The normality assumption was checked using the Shapiro-Wilk test. The Kruskal-Wallis test was used to compare the groups, and significant differences were analyzed using Dunn's post-hoc test. The Fisher-Freeman-Halton exact test was used to examine the relationship between categorical variables and gestational age at the time of diagnosis. A p-value of <0.05 was considered statistically significant.

Results

Of a total of 192 pregnant women included in the study, the mean age was 28.92±5.57 (range, 17 to 44) years, and the

Table 2. Categorical Variables According to Gestational Age

	Gestationalage at the time of diagnosis						P*
	Week<12		Week 12-24		Week>24		
	n	%	n	%	n	%	
Systemic disease history							
Yes	1	7.7	4	12.9	21	15.3	0.933
Total	13		31		137		
Smoking							
Yes	2	14.3	3	9.7	11	8.0	0.536
Total	14		31		137		
Drug use history							
Yes	2	14.3	3	9.7	15	10.9	0.835
Total	14		31		137		
Symptom on admission							
Yes	9	75.0	26	96.3	115	84.6	0.109
Total	12		27		136		
Drycough							
Yes	5	33.3	16	48.5	82	56.9	0.172
Total	15		33		144		
Dyspnea							
Yes	1	6.7	9	27.3	49	34.0	0.045
Total	15		33		144		
Loss of taste and smell							
Yes	3	20.0	4	12.1	30	20.8	0.562
Total	15		33		144		
Fatigue							
Yes	5	33.3	12	36.4	65	45.1	0.527
Total	15		33		144		
Diarrhea							
Yes	1	6.7	4	12.1	14	9.7	0.911
Total	15		33		144		
Sorethroat							
Yes	3	20.0	9	27.3	35	24.3	0.876
Total	15		33		144		
Nasal congestion							
Yes	0	0.0	1	3.0	28	19.4	0.013
Total	15		33		144		
Asymptomatic disease							
Yes	6	40.0	6	18.2	26	18.1	0.154
Total	15		33		144		
Thrombocytopenia							
Yes	2	13.3	3	9.1	27	18.8	0.411
Total	15		33		144		
Lymphopenia							
Yes	11	73.3	14	42.4	86	59.7	0.089
Total	15		33		146		
Thoracic CT							
CT positivity	2	13.3	1	3.0	18	12.5	0.097
Total	15		33		144		
CXR							
CXR positivity	1	6.7[a]	6	18.2	52	36.1	0.002
Total	15		33		144		

Data are given in number and frequency, unless otherwise stated: COVID-19: novel coronavirus-2019; CT: computed tomography; CXR: chest X-ray; *Fisher-Freeman-Halton Exact test and Z-test with Bonferroni correction.

Table 3. Distribution of patients with positive COVID-19 findings as assessed by thoracic CT and/or chest X-ray

Variable		CT			CXR		
		Gestational age at the time of diagnosis					
		Week <12 (n=2)	Week 12-24 (n=1)	Week >24 (n=18)	Week <12 (n=1)	Week 12-24 (n=6)	Week >24 (n=52)
		n	n	n	n	n	n
Unilateral	Yes	0	0	0	0	2	13
Bilateral	Yes	2	1	18	1	4	40
Multilobar	Yes	2	1	18	1	5	44
Single lobular	Yes	0	0	0	0	1	9
Nodular	Yes	1	0	4	1	0	5
Patchy	Yes	2	1	17	1	6	52
Cord-like	Yes	0	0	1	0	0	0
Spider-web	Yes	0	0	1	0	0	0
Ground-glass opacity	Yes	1	1	17	1	6	52
Air bronchogram	Yes	0	0	4	0	0	1
Consolidation	Yes	1	1	8	1	0	9
Crazy-paving	Yes	1	0	5	1	0	3
Pleural effusion	Yes	0	0	2	0	0	0
Pleural thickening	Yes	0	0	1	0	0	0
Lymphadenopathy	Yes	1	0	2	0	0	2

Data are given in number, unless otherwise stated: COVID-19: novel coronavirus-2019; CT: computed tomography; CXR: chest X-ray.

mean gestational age at the time of COVID-19 diagnosis was 37.9±4.19 (range, 10 to 41) weeks. Two patients had multiple pregnancies, and the remaining patients had a singleton pregnancy. Twenty-one patients (14%) had a history of chronic disease (asthma, n=6; chronic hypertension, n=2; diabetes mellitus, n=7; hypothyroidism, n=1; heart failure, n=1; epilepsy, n=1; ankylosing spondylitis, n=1; familial Mediterranean fever, n=1; past history of lymphoma, n=1). Sixteen patients (8.8%) were smokers.

Twenty-five patients (14.3%) were asymptomatic at the time of admission, while the most common symptom was dry cough in 103 patients (53.6%). The data of the patients according to gestational age are summarized in Table 1. Accordingly, the median D-dimer level was the lowest in the first trimester group (<12 weeks) and the highest in the third trimester group (>24 weeks). There was no significant difference in the mean procalcitonin levels between the first and the third trimester groups, while the mean procalcitonin level was significantly lower in the second trimester group (12-24 weeks) (p=0.008). Also, the mean white blood cell (WBC) count was significantly higher in the third trimester group (>24 weeks) than in the first trimester group (<12 weeks) (p=0.036). However, there was no significant difference in the mean WBC count between the second trimester group (12-24 weeks) and the other two groups (p=0.036).

Categorical data of the patients according to gestational age are presented in Table 2. Accordingly, the symptoms at the time of diagnosis other than dyspnea did not significantly differ (p=0.045 and p=0.013, respectively). Ninety-eight patients underwent radiological imaging studies. Of the 98 patients who underwent radiographic imaging, 24 (12.5%) were examined by thorax tomography, while chest radiography was performed on 90 (46.8%), and both chest X-ray and thorax tomography were taken in 16 (8.3%) of them. Findings suggestive of COVID-19 pneumonia were found in 59 (65%) out of 90 patients who had their chest radiography taken, while the chest radiography results of the rest 31 (35%) patients were reported as normal. The most common findings were bilateral (n=45, 50%) and multilobar (n=50, 55%) lung involvement, patchy involvement (n=59, 65%), and ground-glass opacities (GGOs) (n=59, 65%).

Thoracic CT revealed findings suggestive of COVID-19 pneumonia in 21 patients (87.5%), while thoracic CT scans were reported as normal in three patients (12.5%). The most common findings suggestive of COVID-19 pneumonia were bilateral (n=21, 87.5%) and multilobar (n=21, 87.5%) lung involvement, patchy involvement (n=20, 83.3%), and GGOs (n=19, 79.1%). Consolidation was observed in 10 patients

(41.6%) who were found to have pneumonia on thoracic CT scans, while six patients (25%) had a crazy-paving stone pattern (GGOs with superimposed intralobular or interlobar septal thickening), two patients (8.3%) had pleural effusion, three patients (12.5%) had mediastinal lymphadenopathy (LAP), and one patient (4.1%) had pleural thickening. In addition, despite normal chest X-ray findings, thoracic CT scans revealed positive findings in two patients.

Of the 144 patients who were in the third trimester (>24 weeks of gestation), thoracic CT was performed in 19, and 18 of them had findings suggestive of COVID-19 pneumonia. In this group, 79 patients underwent chest X-ray, and 52 had findings suggestive of COVID-19 pneumonia. Of the patients in the second trimester (12-24 weeks of gestation), two underwent thoracic CT, and one had findings suggestive of COVID-19 pneumonia. In this group, nine patients underwent chest X-ray, and six had findings suggestive of COVID-19 pneumonia. Of the patients in the first trimester (<12 weeks of gestation), three underwent thoracic CT, and two underwent chest X-ray, which revealed findings suggestive of COVID-19 pneumonia in two and one patient, respectively. Table 3 summarizes the distribution of pregnant women classified according to the gestational age at the time of diagnosis with positive findings on thoracic CT and chest X-ray. Accordingly, bilateral, multilobar, patchy lesions, and ground-glass opacities (GGOs) were the most common lesions in pregnant women undergoing both chest X-ray and thoracic CT. The least common findings were cord-like opacities, spider web sign, pleural effusion, pleural thickening, and lymphadenopathy (LAP).

Discussion

In the present study, we examined radiological findings on chest X-ray and thoracic CT scans in pregnant women with COVID-19. The most common findings in the two imaging methods were bilateral and multilobar lung involvement, ground-glass opacities (GGOs), and a patchy involvement pattern. Consistent with previous studies comparing pregnant and non-pregnant women, the rate of bilateral and multilobar involvement was similar, but the rate of GGOs was lower and the rate of consolidation was higher. This can be attributed to the fact that pregnant women are more prone to more severe lung involvement and increased consolidation due to hormonal and immune system alterations and anatomical and physiological changes during pregnancy, as well as the atypical course of COVID-19 in this population.

Cardiovascular and physiological immune system alterations during pregnancy make pregnant women vulnerable to infections. The changes in cellular immunity also increase susceptibility to infections caused by intracellular microorganisms such as viruses. The SARS-CoV-2 has an affinity for angiotensin-converting enzyme (ACE-2) receptors found in abundant amounts in type 2 alveolar cells. Upon entering type 2 alveolar cells, SARS-CoV-2 produces diffuse alveolar damage that results in exudation in alveolar spaces[16]. This appears as widespread blurriness concealing vascular signs and resembling GGOs on chest X-ray and thoracic CT scans[17]. Exudation occurs as a result of ongoing apoptosis in alveolar cells, appearing as consolidation with more intense opacity on chest X-ray.

Chest X-ray is the fundamental imaging method widely used in the evaluation of symptomatic patients with suspected or confirmed COVID-19. Exposure to ionizing radiation is not recommended during pregnancy. However, current guidelines recommend the use of thoracic CT, if clinically indicated, provided that the radiation dose from a single scan remains below the threshold that may cause teratogenic effects by taking appropriate precautions[18].

In the initial periods of the COVID-19 pandemic, thoracic CT scans were frequently used in many patients, including pregnant women[17,19]. With the accumulated data about the disease and easily accessible RT-PCR test kits, the use of thoracic CT has been restricted in most centers. The selection of the imaging method (chest X-ray or thoracic CT) in the present study was based on the diagnostic performance of the methods, gestational age, and the clinical condition of the patient.

In the present study, 90 patients with a positive RT-PCR test result underwent chest X-ray, revealing abnormal findings in 59 patients (65%). Chest X-ray showed normal findings in 31 patients (35%). Thoracic CT scans revealed positive findings in two patients with normal chest X-ray. Negative chest X-ray may arise from the absence of pulmonary involvement, acquisition of images in the early disease periods, mild involvement that is below the detection limit of resolution in X-ray films, or technical issues. Therefore, normal chest X-ray may not necessarily rule out COVID-19 pneumonia[20]. The most common chest X-ray findings in the present study were bilateral (50%) and multilobar (55%) lung involvement, patchy involvement (65%), and ground-glass opacities (GGOs) (65%). Ten patients (11.1%) also had consolidation. These findings are consistent with those reported in smaller cohorts of patients[21].

The most common thoracic CT findings in the present study were bilateral (87.5%) and multilobar (87.5%)

lung involvement, patchy involvement (83.3%), and ground-glass opacities (GGOs) (79.1%). Consolidation was observed in 10 patients (41.6%) who were found to have pneumonia on thoracic CT scans. In a systematic review of 919 adults, Salehi et al.[13] reported bilateral pulmonary involvement in 87.5%, peripheral involvement in 76.0%, and posterior pulmonary involvement in 80.4% of the patients. In addition, 88.0% of the patients presented with GGOs and 31.8% with consolidation. Unlike this study, these rates were relatively low in our study (79.1%) with an increased rate of consolidation (41.6%). In a systematic review including 427 pregnant patients with COVID-19, the rate of bilateral pulmonary involvement was slightly lower with a lower rate of GGOs and a higher rate of consolidation in pregnant women than in the general population[22]. Similarly, a few studies including a small number of patients showed a higher rate of consolidation in pregnant patients than in non-pregnant patients[23].

In the aforementioned systematic review, the prevalence of pleural effusion was higher among pregnant patients than in non-pregnant patients (30% vs. 5%, respectively). The authors suggested that, although there was a limited number of data regarding the prevalence of pleural effusion during pregnancy, pregnancy was a known risk factor for pleural effusion, and the prevalence of pleural effusion was three times higher in COVID-19 patients compared to asymptomatic pregnant women. These results suggest that pregnant women may be prone to presentation in the advanced disease stages considering the fact that consolidation and pleural effusion are indicators of more severe disease progression[22]. In another study, Liu et al.[21] found a higher rate of pleural effusion in pregnant women. However, some of the patients were in the early postpartum period, and pleural effusion is a common complication of vaginal delivery within the first 24 hours, which can explain the higher rates. In our study, the rate of pleural effusion was similar in pregnant women to the general population (8% vs. 5%, respectively).

In our cohort, most imaging studies were performed in the third trimester of pregnancy. There was an increased rate of bilateral and multilobar involvement, ground-glass opacities (GGOs), and a patchy involvement pattern in the third trimester. Also, we observed an increase in the frequency of consolidation and the crazy-paving stone pattern in the third trimester, the latter being the finding of acute respiratory distress syndrome (ARDS). These findings can be attributed to the progressively expanding gravid uterus and relatively insufficient expansion of the rib cage, and decreased functional capacity[23,24]. A study comparing pregnant and non-pregnant women infected with SARS-CoV suggested that two-thirds of the deaths among the pregnant women occurred in the second or third trimester, when these physiological alterations became the most prominent[23].

Theoretically, these changes may also increase the risk of developing serious complications of COVID-19 by decreasing the ability to clear secretions, thereby leading to an increased likelihood of consolidative pneumonia. Another theory proposes that the change in the immune system functions during pregnancy makes patients vulnerable to acute pulmonary injuries[23,25]. All these findings can explain why patients in the third trimester of pregnancy manifest more clinical symptoms, and more often require imaging studies, as reported in the present study. However, generalizing our data on the rate and distribution of positive findings can be misleading due to the low number of patients undergoing chest X-ray and thoracic CT in the first (<12 weeks) and second trimesters (12-24 weeks).

Nonetheless, there are some limitations to this study. First, it has a single-center, retrospective design. Second, the sample size is relatively small. In particular, the number of patients undergoing both chest X-ray and thoracic CT in the first and second trimesters and the number of those undergoing thoracic CT are considerably low. Further multi-center, large-scale studies are needed to confirm these findings.

Conclusion

Our study results suggest that pregnant women with COVID-19 have similar radiological findings to non-pregnant COVID-19 patients, with the most common findings being bilateral and multilobar involvement. Despite low ground-glass opacity (GGO) rates, consolidation is increased in this population. However, there is a need for well-designed, large-scale, long-term studies including pregnant women diagnosed with COVID-19 to draw reliable conclusions on this subject.

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