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Characteristic Abdominal Imaging in Positive Obese SARS-COV-2 Patients

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ABSTRACT

Background/aim: The fatal potential of the SARS-COV-2 pandemic is its association with multiple clinical presentations, beyond the chest manifestations. The gastrointestinal manifestations were detected in patients and could be imaged using ultrasonography and CT of the abdomen. Obesity is a major risk factor for adverse outcomes of SARS-CoV-2 infection specifically abdominal (visceral fat). **This study aims** to highlight the abdominal imaging findings in patients with SARS-COV-2 (COVID-19) and evaluate the association between the severity of COVID-19 outcomes with general (BMI) & abdominal (visceral) adiposity. **Subject and Methods:** This is a cross-section study done on 1500 Egyptian patients; 780 males and 720 females, aged from 28 to 70 years old. The patients were classified according to manifestations into two groups (chest and gastrointestinal) and according to BMI; normal-weight (n = 300), overweight (n = 385) and obese (n = 485). Then abdominal imaging using sonographic and CT examination was done, as well as assessing of visceral fat and finding its correlation with manifestations. **Results:** This study revealed that 740 patients had chest manifestation, 430 patients had gastrointestinal manifestations and 330 patients (22%) were admitted to the intensive care unit (ICU). There was an insignificant sex difference. The cough (92%) and fever (96%) were mostly common with chest manifestations. While diarrhea (73%) and abdominal pain (71%) were the commonest gastrointestinal manifestations. These manifestations were more frequently noted in obese, moreover dilated bowels with thickened walls. While gall bladder distension was noted frequently in overweight patients. There was a significant increase in visceral fat area in obese patients with GI manifestation. There was a positive correlation between gastrointestinal manifestations with BMI and visceral fat. While insignificant correlation with total abdominal fat and subcutaneous fat areas, **Conclusion:** Abdominal imaging had an important role in early diagnosis of COVID-19. Gastrointestinal manifestations of SARS-COV-2 (COVID-19) have been recognized frequently. Patients had critical conditions are obese with higher abdominal visceral fat.

Keywords: Abdominal imaging, obese, COVID-19

1. Introduction

The novel of the severe acute respiratory syndrome coronavirus-2 (SARS-COV-2) pandemic was started in the last month of 2019 and has resulted in more than 194 million cases of hospitalizations occurred (Huang *et al*., 2019). The most common COVID-19 symptoms are; cough (67%), fever

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(91%), dyspnea (30%) and fatigue (51%). Gastrointestinal (GI) symptoms were detected in some patients in the early stages (Liang *et al*., 2020). The gastrointestinal manifestations have been reported in those patients including; ileus, bowel ischemia, bleeding, abnormal liver function, pancreatitis, acute hepatitis, a calculus cholecystitis, cholestasis and cholangitis (Bhayana *et al.,* 2020). Some patients have presented with GI symptoms only at the initial presentation and /or without respiratory symptoms in some cases (Liang *et al*., 2020).

SARS-COVID-2 is thought to gain access to the cells via surface expression of angiotensin-converting enzyme 2 (ACE2). Thus, tissues with high levels of ACE2 expression are assumed to be susceptible to direct infection as, lung alveolar epithelial cells, enterocytes of the small intestine, the vascular endothelium and white adipose tissue (visceral fat) (Wang *et al.*, 2020). Several studies evaluated chest findings in patients with COVID-19, leading to a greater understanding of pathogenesis in the lung and abdominal manifestations (Bernheim *et al.,* 2020).

Recognizing risk factors is of utmost importance, obesity was implicated as a clinically significant risk factor for severe disease (Kwok *et al.,* 2020). Multiple studies have supported this theory, and several researches on this subject have been published (Wang *et al.*, 2020), (Földi *et al.,* 2020). Obesity and overweight have been identified as risk factors contributing to the development of severe illnesses that lead to hospitalization for COVID-19 infection (Petrakis *et al*., 2020). Obesity worsens outcomes from COVID-19; adults and children with excess weight are at greater risk from COVID-19 because it is linked to impaired immune function and decreased lung capacity which consequences to difficult ventilation. Although most COVID-19 cases suggest that hospitalization risk, admission to the intensive care unit, invasive mechanical ventilation, and death are increased with increasing weight (Griffith *et al.,* 2020). In addition in abdominal obesity, visceral fat (VF) show a higher expression of ACE 2 than subcutaneous fat (SCF) in patients with severe obesity (Yang *et al.,* 2020). We aim in this study to highlight the abdominal imaging findings in patients with COVID-19 and evaluate the association between the severity of COVID-19 outcomes with general (BMI) & abdominal (visceral) adiposity.

2. Materials and methods

Study Design

This study was a cross-sectional design and was approved by the research ethics committee at the Faculty of Medicine, Helwan University [No: 150-2022]. The study followed the Declaration of Helsinki guidelines on the conduct of human research. Informed written consent was designed by each patient.

Participants

One thousand and five hundred and twelve patients were included in this study; they were diagnosed with positive SARS-CoV-2 and admitted to the hospital and informed their right to refuse or withdraw at any time and about the confidentiality of any obtained information.

Inclusion and Exclusion Criteria

The participants' age 20-70 years old, included Egyptian females. Patients who tested positive PCR test for (SARS-CoV-2) and presented with abdominal symptoms. Positive abnormal laboratory studies. The participants were excluded if they had a positive PCR test for (SARS-CoV-2) without abdominal manifestations or with a history of prior chronic disease e.g., chronic renal or hepatic diseases.

Outcome measures

Clinical assessment

The main outcomes were admission to the intensive care unit (ICU) and intubation.

Patients were classified according to body mass index (BMI) to normal weight ($\leq$ 24.9 kg/m^2), overweight (25-29.9 kg/m^2) and obese (BMI $\geq$30 kg/m^2). BMI was calculated by dividing the weight by the height squared (Kg/m^2), as the weight & height were taken using the scale balance and the Holtain anthropometer respectively, according to the International Biological Program recommendations (Hiernaux, 1969).

Ultrasonography examination and interpretation

The ultrasonography examination was done using PHILIPS, USA, using CX-30 portable machine with a convex probe 5-MHz, the patient was examined in the supine position.

Findings were; gall bladder sludge and distension (suggestive of bile stasis), fatty liver, portal vein gas and dilated bowel with reduced peristalsis.

Abdominal visceral fat assessment*:* measures visceral fat thickness in cm at the umbilical region; as a distance between the muscle inner surface of the abdominal rectus muscle and the posterior wall of the aortic artery.

Computed Tomography CT examination

Non-contrast abdominal CT scan, the patient was in a supine position with elevated arms up, using: Toshiba 128-slice multidetector CT scanners, with scanning parameters (120 KV, 300 MA, collimator width of (64 x 0.625 mm), pitch of 0.8, gantry rotation time of 0.5 second and field of view of 50 cm).

Contrast-enhanced CT: Patient preparation (six hours fasting). The patient was injected with about 100 ml of non-ionic iodinated contrast material at an ante-cubital intravenous cannula using an automated injector with a 3 ml/sec injection rate and scanning was done after 70 seconds of contrast administration. Acquisition of the axial images at arterial and Porto-venous phases, followed by reconstructed coronal and sagittal reformatted images.

Findings: Bowel wall abnormalities; bowel wall thickening, portal venous pneumatosis or gas, pneumatosis-intestinal, perforated small bowel, fluid-filled colon and acute infarction of solid organs.

Abdominal fat assessment: Advanced processing at the workstation (AW Volume share2-version 4.4 Software) for the abdominal cut: total fat area (TFA), subcutaneous fat area (SFA) and visceral fat area (VFA) were measured.

Data collection and image analysis: To reduce the subjective judgment and reach a proper diagnosis; the following definitions were respected:

- Fatty liver, distended gall bladder (transverse diameter more than or equal to 4 cm), thickened wall of the gall bladder ≥ 3 mm and sludge on gall bladder.
- Fluid-filled colon and bowel wall thickening on CT images (a single wall thickening ≥ 3 mm in distended loops and ≥ 5 mm in collapsed loops).
- Pneumatosis, as gas density whether inside the bowel wall or PV.

Statistical Analysis

The data was analyzed using the Statistical Package for Social Sciences (SPSS/Windows Version 22, IBM Corporation). Parametric data is expressed as mean ± standard deviations (SD), while the non-parametric data (qualitative) is expressed as a frequency distribution (numbers). Comparisons chest and GIT manifestations, as well as BMI and abdominal fat (visceral fat). Pearson correlation test was used to examine the association and correlation with BMI and abdominal fat (r: Spearman correlation coefficient). $P < 0.05$ (a Statistical significance).

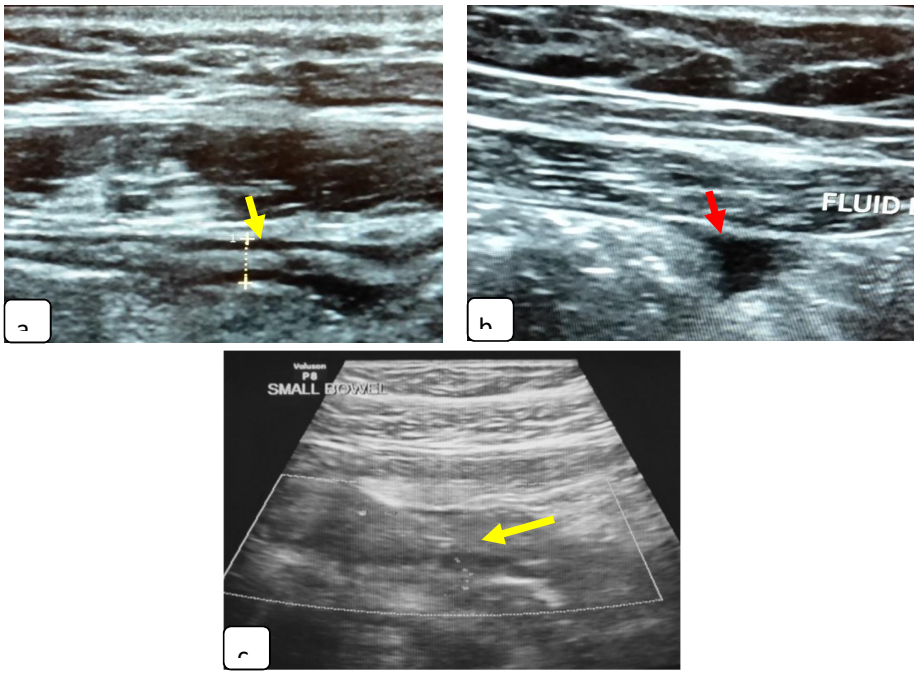

Fig. 1: A 42-year-old obese female patient complained of abdominal pain. Transverse abdominal scans (a, b and c) show dilated bowel loops with thickened walls (yellow arrows) and fluid is noted (red arrow). There is also an increased visceral fat area (6.2 cm).

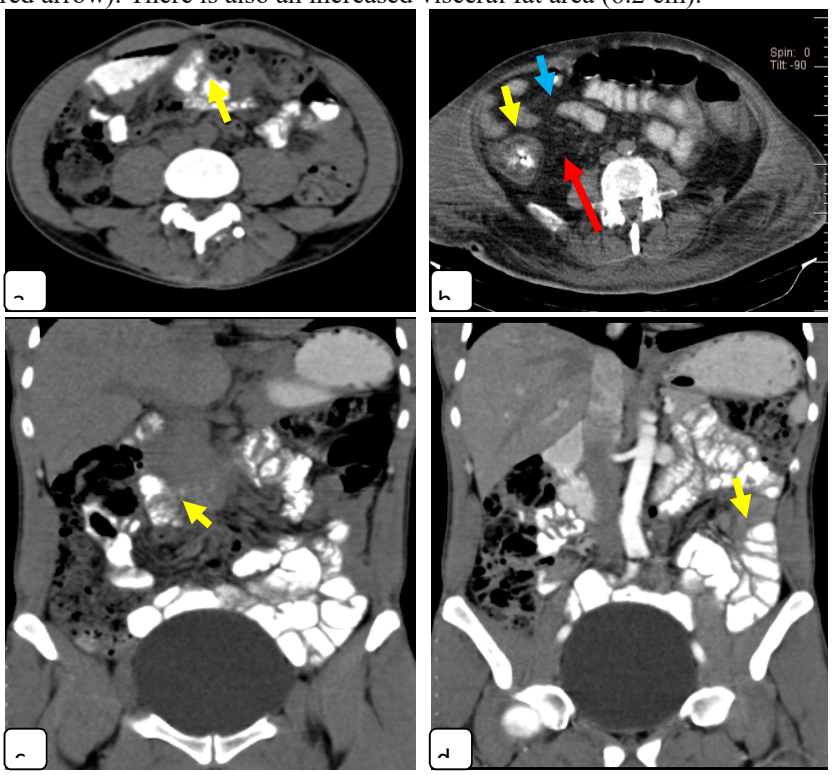

Fig. 2: A 46-year-old overweight male patient complained of diarrhea and abdominal pain. (a) Axial abdominal CT image shows thickened small bowel wall (yellow arrow), (b) axial CT image shows thickened colonic wall (yellow arrow), mesenteric fat stranding (below arrow) and increased visceral fat area (red arrow). (c & d) coronal CT images show thickened walls of the small bowel and colon (yellow arrow) respectively.

3. Results

The present study comprised 1500 Egyptian patients, who tested positive for SARS-COV-2 and were admitted to our institution during the study period (780 males and 720 females); their age (28-70 years, mean 54.6 years ± 14.8 SD) for males, (20-68 years, mean 49.2 years ± 11.8 SD) for females. Their weight mean was (91.3 ± 8.6 kg SD & 86.2 ± 12.3 kg SD) and the height mean was (161.6 ± 8.2 cm SD & 157.6 ± 7.6 cm SD), for males and females respectively. There 740 of those patients had chest manifestation (380 males and 360 females) (Group 1), 430 patients had GI (220 males and 210 females) (Group 2) and 330 patients (22%) were admitted to the intensive care unit (ICU) which was excluded. So, there were1170 patients within two groups, with insignificant different changes regarding both sexes. The cough and fever were most common with chest manifestation representing 92% and 96% respectively. While diarrhea and abdominal pain were the commonest gastrointestinal manifestations representing 73% and 71% respectively **(Table 1)**. Then they were classified into three groups according to BMI; normal-weight (n = 300) (180 males & 120 females), overweight (n = 385) (200 males & 185 females) and obese (n = 485) (220 males & 265 females) **(Figure 3)**.

Table 1: Demographic and clinical data frequency distribution According to chest and gastrointestinal Manifestations.

Variable	Chest Manifestations No. & %	Gastrointestinal Manifestations No. & %	*p*-value
	740 (63.2%)	430 (36.75%)	
Males (No. & %)	380 (32.4%)*	220 (18.8 %)	0.05
Females (No. & %)	360 (30.8%)*	210 (17.9 %)	0.05
Chest Manifestations			
Fever	680 (92%)*	375 (87%)	0.00
Cough	710 (96%)*	280 (65.1%)	0.00
Gastrointestinal Manifestations			
Diarrhea	185 (25%)	314 (73%)*	0.00
Vomiting	355 (48%)	292 (68%)*	0.00
Nausea &Loss of appetite	392 (53%)	279 (65%)*	0.00
Abdominal pain	244 (33%)	305 (71%)*	0.00

* P ≤ 0.05 Significant

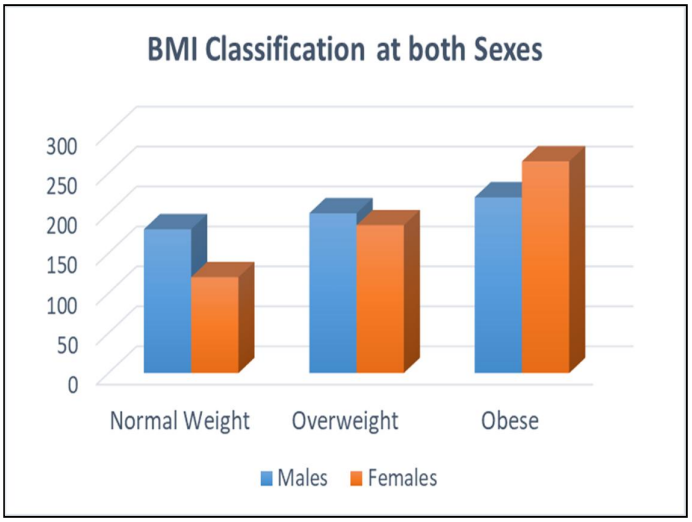

Fig. 3: BMI classifications of both sexes; normal weight (24.30%), overweight (29 %), obese (31%).

Table 2: Association between BMI and chest & gastrointestinal manifestations

Variable	BMI				
	Total	Normal-weight No. & %	Overweight No. & %	Obese No. & %	*p*-value
	1170	300 (25.6 %)	385 32.9%)	485 (41.5%)	
Sex					
Males (No. & %)	600 (51.3%)	180 (15.4 %)	200(17.1 %)	220(18.8 %)*	0.05
Females (No. & %)	570 (48.7%)	120 (10.2 %)	185 (1.4 %)	265(22.6 %)*	0.05
Chest manifestations	740 (63.2%)	180 (15.4%)	245(20.9%)	315(26.9%)*	0.00
Gastrointestinal Manifestations	430(36.7%)	120 (10.2%)	140 (12 %)	170 14.5 %)*	0.00

* P ≤ 0.05 Significant

The association between BMI and chest & gastrointestinal manifestations was done and found that obese males and females were mostly frequent with chest and gastrointestinal manifestations **(Table 2)**. Also, the association between BMI and sonographic and CT abdominal assessment, revealed that the dilated bowel and thickened wall was mostly detected within obese patients, while gall bladder distension was noted frequently in overweight patients. Regarding visceral fat, there was a significant increase in visceral fat area detected by sonography and CT in obese patients with GI manifestation compared to normal-weight patients, as well as total abdominal fat area by CT, and insignificant changes with subcutaneous fat **(Table 3)**.

The correlation between gastrointestinal manifestations and BMI & abdominal fat was done and revealed a positive relationship between gastrointestinal manifestations with BMI and visceral fat. While an insignificant correlation with total abdominal fat and subcutaneous fat areas, as shown in (**Table 4).**

Table 3: Association between BMI and sonographic and CT abdominal assessment

Variable		BMI			
	Total	Normal-weight No. & %	Overweight No. & %	Obese No. & %	*p*-value
	1170	300 (25.6 %)	385 (32.9%)	485 (41.5%)	
Sonographic Abdominal Assessment					
Dilated Bowel	375 (32.0%)	80 (6.8 %)	115 (9.8 %)	180 (15.4 %)*	0.05
Abnormal wall thickness	370 (31.6%)	100 (8.5 %)	105 (9.0 %)	165 (14.1 %)*	0.05
Dilated gall bladder	468 (40%)	60 (5.2%)	225(19.2%)*	183 (15.6%)	0.05
Visceral fat area (cm)	1170 (100%)	5.8+1.9	6.1+3.7	6.4+3.9*	0.05
CT Abdominal Assessment					
Dilated fluid filled colon	445 (38.0%)	81 (6.9%)	134 (11.5%)	230 (19.6%)*	0.00
Thickened colonic wall	438 (37.4%)	114 (9.7%)	121 (10.3%)	203 (17.4%)*	0.00
Total abdominal fat (cm^2)	1170 (100%)	674.3 ±126.5	704.6 ±131.7	765.5 ± 132.2*	0.05
Subcutaneous Abdominal fat (cm^2)	1170 (100%)	287.6±146.8	315.4±145.3	325.2 ±165.1	0.06
Visceral Abdominal fat (cm^2)	1170 (100%)	146.5±40.5	157.1±40.2	168.3 ±45.2*	0.05

* P ≤ 0.05 Significant

Table 4: Correlation between gastrointestinal manifestations and BMI abdominal fat

Variable	Gastrointestinal Manifestations	
	R	*P*-value
BMI	0.267	0.05*
Visceral fat area	0.284	0.01*
Total abdominal fat	0.064	0.25
Subcutaneous Abdominal fat	0.087	0.15
Visceral Abdominal fat	0.286	0.03*

* $P \leq 0.05$ Significant

4. Discussion

The SARS-COV-2 infection could present with abdominal manifestations and gastrointestinal symptoms at its onset including; nausea, abdominal pain, vomiting, loss of appetite and diarrhea (Liu *et al*, 2020; Cheung *et al.,* 2020). In this study, diarrhea was the most common gastrointestinal finding (73%), diarrhea should be in consideration as an important symptom during a patient's admission. It was diagnosed by ultrasonography as a dilated bowel with abnormal wall thickness (32%) and dilated fluid-filled colon on CT images (38%). Although the finding of gall bladder stasis of bile was detected in 40% of patients by ultrasonography.

These findings were in agreement with Goldberg Stein *et al*. (2020) and Bhayana *et al.* (2020), who found that the most common abdominal finding was fluid-filled colon, with the abnormal bowel wall thickness seen in 31% of patients and fluid-filled colon in 43%. Some studies found that 37% of patients had abdominal manifestations (Mavropoulou *et al*., 2023). Many studies demonstrated that bowel wall abnormalities detected on 31% of abdominal CT scans, such as pneumatosis. While abdominal ultrasonography could detect 54% of these abnormalities. This was considering the susceptibility of small bowel infection by SARS-COV-2 (Zou *et al.,* 2020).

Evidence of its risk has lately increased with a worse prognosis, especially if it is associated with obesity. This could be explained by that the increased adipose tissue in obesity can amplify the pro-inflammatory response to viral infection by direct, indirect and epigenetic mechanisms, ranging from attenuation of immune system activity to chronic inflammation (Behl *et al.,* 2022); Lymphocyte cells response are impaired in obese individuals, leading to increase susceptibility for viral infection. Also, under viral infection, there is a dysregulated response leading to reduced macrophage activation (Shaikh, 2022). Moreover, obesity could increase antiviral resistance (Behl *et al.,* 2022). Therefore, all these factors get the adipose tissue especially the visceral tissue, capable of provoking the acute disease through augmentation of the inflammatory process (Kawai *et al.,* 2020).

In this study, the association between body mass index (BMI) and SARS-COV-2 infection was assessed and revealed that obesity is a risk factor for worse outcomes. Patients with a BMI > 30 kg/m2 have a higher risk for respiratory and abdominal complications. These agree with a study performed in New York, that found a greater risk for admission at the hospital, for patients with BMI ≥ 30 and a greater risk for the intensive care unit for those with a BMI ≥ 35 (Lighter *et al.* 2020). Although BMI is the commonest indicator used to assess overweight and or obesity with high (Fryar *et al*., 2020). While it couldn't distinguish between visceral and subcutaneous abdominal fats. Here, ultrasonography and CT are non-invasive methods that enable to differentiate and quantitative of visceral and subcutaneous fat tissues (Yang *et al*., 2020).

In this study regarding abdominal adiposity, the visceral fat (VF) had a significant association with SARS-COV-2 severity, and insignificant association with subcutaneous fat. So, high visceral fat could be used as a predictor of severe COVID-19. Also, it could be noted that normal-weight patients could have high visceral fat. There are many theories that could explain how abdominal obesity may lead to adverse outcomes in SARS-COV-2 infection as; VF can produce different inflammatory substances, which impair the immune system function (Iannelli *et al*., 2020) and increased release of inflammation-inducing leptin, with decline production of protective adiponectin. Moreover, visceral adiposity is associated with a complex pro-coagulant and a suppressed fibrinolytic profile, through many mechanisms as; extensive endothelial damage, and production of plasmin activator inhibitor-1, which can lead to thrombotic complications in SARS-COV-2 infection (COVID-19) (Safari *et al*., 2020). Previous research had focused on BMI only and found that increased severity of COVID-19 was associated with high BMI, without distinguishing between visceral and subcutaneous adipose

tissue. Apart from overall obesity, body fat distribution is an important risk factor for many health problems (Richardson *et al.,* 2020). Visceral adipose tissue is often associated with metabolic syndrome, conferring an increased risk with subsequent higher morbidity (Simonnet *et al.,* 2020).

Going established a correlation between BMI-based general obesity and severe courses of COVID-19 our results suggest that body fat distribution is also decisive, with visceral adipose tissue increasing the risk for severe courses of COVID-19. Hence, CT-based quantification of visceral adipose tissue might be used as a simple tool for risk assessment in SARS-CoV-2 patients from routinely acquired chest CT scans.

5. Conclusion and Clinical Implication

Abdominal imaging had an important role in early diagnosis of COVID-19. Gastrointestinal manifestations of SARS-COV-2 (COVID-19) have been recognized frequently. Patients had critical conditions are obese with higher abdominal visceral fat.

Conflict of interest
The authors state no conflict of interest.

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Author contribution
Safenaz Y. El Sherity (corresponding author): Design of the work, Analysis &interpretation of the data and revising it critically for important intellectual content. **Reham I. Siddik*:*** Clinical assessment and Acquisition of the data. **Alshaimaa M. AbdelMoaty:** Acquisition of the data. **Sondos M. Salem:** Clinical assessment. **Shymaa A. Shalaby:** Drafting the work and radiological assessment. All authors shared in design of the work and final approval of the publish version.

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