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A low-dose chest CT protocol to diagnose and discriminate COVID-19 from other infections compared to a standard dose

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Abstract

Purposal: The general goal of the present paper is determining whether or not image quality of low-dosage protocol MDCT scanning of the chest in the COVID-19 has any considerable differences to the image quality of standard-dose protocol that has been based upon the subjective assessments, for diagnosing and managing COVID-19 patients.

Methods:A standard automodulation protocol of 50mAs – 210mAs has been carried out for all of them (243) patients. The 0.5 sec. rotation time. Of 243 patients whose computed tomography scan have shown COVID-19 infection signs, 141 of the patients that were older than 49 years old have been chosen. Low dosage computed tomography scans (30mAs) have been carried out on those patients right away.

Results: Out of 243 COVID-19 patients that are older than 49 based on PCR have undergone a computed tomography scan of the chest, only 141 of them have shown COVID-19 signs.In comparison with the standarddosage, lowdosage have shown very good sensitivity in the detection of the typical COVID-19 findings (P-values less than 0.05 one reader and P-values less than 0.01 two readers). The average values of the effective dosage have been 6.33±2.83and 1.45±0.30mSv respectively in the standard and low-dosage,

Conclusions: Despitethe limitations of this research, the authors highly recommend employing a low dosage method in all of the non-contracted computed tomography scanning of the chest in the cases of COVID-19 infections.

Keywords: COVID-19, Chest CT, Computed tomography, Low dose.

INTRODUCTION

Throughout the past 20 years, humans encountered 3 considerable outbreaks of the epidemics of the new coronavirus (CoV). The first one had happened in the early 2000s, and it has been a result of severe acute respiratory syndrome (SARS)-CoV(1). The second one had taken place in the 2010's, has been a result of Middle East respiratory syndrome (MERS)-CoV(2). And finally, the present outbreak that has resulted from SARS-CoV2 (which has been also named as the Coronavirus Disease2019 (COVID19) by WHO), which has emerged in Dec. 2019 in China, and resulted in over 150000 death cases by 19th of Apr. 2020(3).The lungs are the organ that is most affected by the COVID-19, and some of the patients could end up developing life-threatening sepsis and viral pneumonia. There have been as well growing evidence for the correlation between COVID-19 and several cardiovascular complications (4). Presently, there is a number of clinical management options that are available for the patients who have COVID-19 with pneumonia, beyond the antibiotic administration and oxygen supply to avoid the co-infections, and potentially,

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via the not recommended, corticosteroids' administration .(5). It should be noted there have been ongoing discussions of a possible utilization of the diagnostic X-ray, most significantly through the CT scans for the COVID-19 associated lung pathologies(6). There have been abundant evidences of the fact that the radiation can cause lung cancer in both genders, with higher risks in the smokers and women than non-smokers and men, respectively. Based on the risk factors that have been assessed by UN Scientific Committee on the Atomic Radiation Effects(7). according to the data of the Japanese atomic bomb survivors, acutely delivered lung dosages of 0.3Gy–1Gy that have been suggested by Mackenzie and Kirkby (2020) would result in the nominal induction of 0.60–4.40 excess lung cancers in 100 exposed individuals(8). Even though the RT-PCR (i.e. the real-time reverse transcriptase polymerase chain reaction) is still COVID-19's standard diagnostic reference, numerous issues like high rates of the false-negative results, delay in the confirmation and limited availability could exist (9) . More particularly, WHO and Disease Control Centers recommend the viral tests (which include the PCR) as the identification approach and lab confirmations of the cases of COVID-19. In spite of the high analytical sensitivity and the almost optimal specificity, the test sensitivity in the clinical practices could be negatively influenced by some of the variables, which include specimen adequacy, specimen handling, specimen type, and the infection stage in which specimen has been obtained (10). False-negative tests of the RT-PCR were stated in the patients with the CT findings of COVID19 that have been tested positive eventually with the serial sampling(11). However, the abnormalities that are related to the computed tomography can predate the positivity of the RT-PCR in the symptomatic patients and the asymptomatic ones that have subsequently tested positive by the RT-PCR.

The spread of the Coronavirus 2020 pandemic in Iraq had started from Feb. 24th, 2020, in Al-Najaf city, where a sample of an Iranian student has been tested and results have been positive for his infection by Corona virus related to SARS2 (SARS-CoV2). After that, other Covid-19 cases have been found, and total confirmed cases in Iraq have reached up to 657453 cases, which include 13220 death cases, by Feb. 18th, 2021.
The present study has been carried out in Iraqi hospital for the X-Ray Institute in the medical City Complex in Baghdad after the spread of the Corona Virus 2020 epidemic.

Patients and Methods

Patient selection

Since the 1st of Oct. 1, 2020, until 30th of Apr., 2021, 243 consecutive patients have been suspected to be having COVID-19 and they had PCR positive referred to the X-Rays Institute in medical City Complex for the MDCT prospective study have been carried out. A total of 141 Patient have been exposed to the standard-dose as well as low-dose chest MDCT without the transfer of the patient to computed tomography table. The non-contrast helical computed tomography scanning has been conducted in the axial sections with the use of A64-row detector multi-slice helical computed tomography system has been utilized for acquiring CT chest (Aquilion CXL- TSX-101 A/Q, Toshiba, Japan) that is able to generate 128 slices in each rotation. The evaluation of the quality of the image has been made by 3 experts (i.e. Consultant Radiologists in the X-rays Institute / Medical City Complex); images from both modalities, in other words, protocols A and B, have been assessed qualitatively for the purpose of ensuring the criteria of the quality for the diagnostic radiographic images.

Criteria of Inclusion

Patients that have been included in the present study were the ones that were referred to in this

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research for suspected COVID-19 infection.Evaluation images quality of each patient's standard dose and the low-dose protocols were performed separately and at different times by three experienced radiologists and the result of the readings between them was about 95% compatible

Criteria of Exclusion

1. Patient that have the interstitial lung disease as well as cancer history.
2. Patients below 44 years old are more radio-sensitive.

Procedure and method

Pre-scanning planning

Initially, an overview of examination steps for every one of the patients has been performed as follows: in the case where one wants to volunteer in a study with CT scan of the chest that will be beneficial in future for the minimization of the radiation to patients, they will be examined twice, the 1st examination with the regular dose will be carried out, and the examination for the 2nd time will be carried out with a low dose which is approximately 1/3 of the dosage. Following obtaining the patient's consent for contributing to the present research, the patient has been suggested to remove any radio-opaque material from the chest area for the purpose of avoiding the objects which would compromise the image quality. In the supine position, scanning is carried out after that.

Scanning and reconstruction protocols.

A 64-row detector multis-lice helical computed tomography system has been utilized for the acquisition of chest CTs (Aquilion CXL- TSX-101A/Q) that can generate 128 slices in each rotation, it has been utilized for scanning non-contrast helical CTs in the axial sections, which include the region that begins in the neck's lower part until diaphragm. The scan has been carried out in the supine position in the craniocaudal manner. Every one of the patients has been scanned twice, first, with the use of regular protocol and after that, with the use of low-dose protocol. The kVp has been identical for the two protocols, equal to 120 kVp. Except for the mAs that have been changed, all the variables have been identical in every one of the tests. In standard-dose protocol, it has been moderate, ranging between (50nAs and 210mAs) and in low-dose protocol it has been equal to 30mAs, all have been carried out in supine position. The photos re-produced in 0.5mm from raw data that has been found for each one of the patients, after that it has been transferred to a CD.

Radiation dose analysis.

When comparing volume CT dosage index (i.e. CTDI) that can be defined as a standardized computation of the CT scanner radiation dosage production and one of the most widely utilized tools for the estimation of the radiation exposure of the patient from the CT process, this tool automatically measured (8.95 mGy) in CT scan of the standard dose and (2.21 mGy) in CT scan of the low dose. This implies that patient radiation exposure will be decreased by 40% - 85% when we decrease the mAs automatic modulation from (50-210) mAs to 30 mAs.

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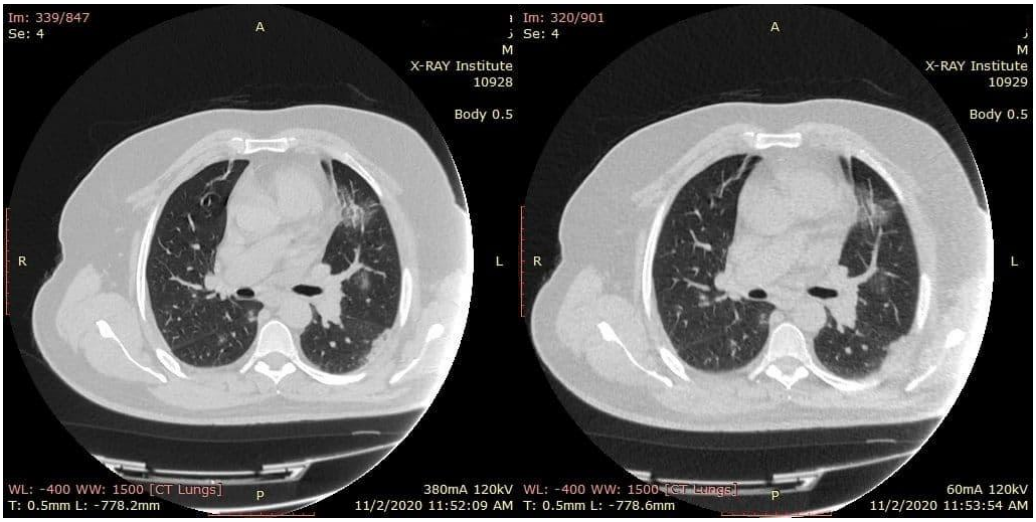
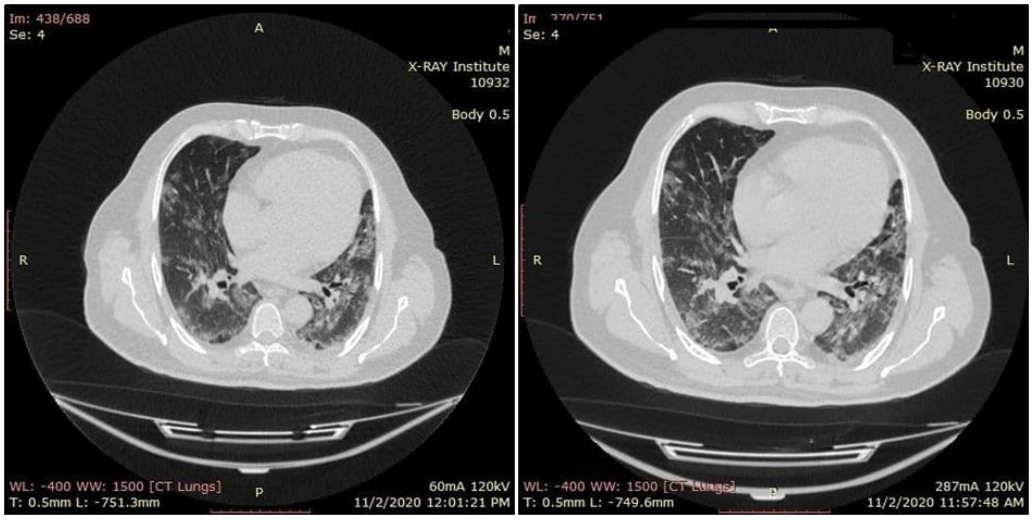
Results



(a) (b)

Figure 3: Chest computed tomography scans of 54-year-old male that had COVID -19; (a) Standard-dose, (b) low-dose images.

Figure 3a, which depicts the standard-dose computed tomography scan, which shows the multi-focal ground-glass chest opacity, mainly in anterior and peripheral regions that are related to inter-lobular septal thickening. While Figure 3b illustrates a low-dose CT scan for that same patient. There has been a consensus amongst the experts for diagnosing it as COVID -19.



(a) (b)

Figure 4: Chest CT scan of a 56-year-old man with COVID -19; (a) Standard-dose image, (b) the low-dose image.

Figure 4a, standard-dose CT scan, showing demonstrated bilateral ill-defined ground glass opacities scattered in both lungs predominantly posterior and peripheral regions associated with interlobular septal thickening "crazy" paving image suggesting COVID 19. Figure 4b, CT scan image using the low-dose, the image with same standard dose markers indicative of COVID 19 infection.

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Table 1: The distribution of study sample according to CT negative finding and CT positive finding and demographic variables N (243)

		CT finding						
		CT negative finding		CT positive finding		Total		P.V
		No	%	No	%	No	%	
age groups	50-59	76	74.51	90	63.83	166	68.31	0.004*
	60-69	18	17.65	48	34.04	66	27.16	
	70-79	8	7.84	3	2.13	11	4.53	
	Total	102	100.00	141	100.00	243	100.00	
Gender of sample	Male	76	74.51	93	65.96	169	69.55	0.153
	Female	26	25.49	48	34.04	74	30.45	
	Total	102	100.00	141	100.00	243	100.00	
Chronic diseases	Diabetic	20	19.6	32	22.7 %	42	17.3	0.0001*
	hypertension	26	25.5	47	33.3%	73	30.0	
	hypertension and diabetic	17	16.7	33	23.4 %	50	20.6	
	renal disease	3	2.9	8	5.7%	11	4.5	
	Negative	36	35.3	21	14.9 %	57	27.6	

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	Total	102	100.00	141	100.00	243	100.00	
Age	Mean±SD=58±6			Mean±SD=58±6				

Table 2: Association between PCR tests with CT finding. N(243).

	CT chest finding					
	CT negative finding		CT positive finding		Total	
	No	%	No	%	No	%
PCR positive	102	41.80	141	58.20	243	100.00
Total	102	41.80	141	58.20	243	100.00

Table 3: Data of radiation dose from standard-dose and low-dose chest CT scan protocols in detection COVID-19 infection.

	Protocol Stander dose	Protocol low dose
CTDIvol(mGy)	8.95±4.06	2.21±0.94
DLP1(mGy·cm)	316.34±141.33	72.56±14.93
Conversion factor (mSv/mGy·cm)	0.020	0.020
Effective dose (mSv)	6.33±2.83	1.45±0.30

TABLE 4: show descriptive CT scan features N(141)

CT scan features	NO	%
GGO	52	36.9
Consolidation	19	13.5
crazy paving	8	5.7
GGO and consolidation	31	22.0
Vascular thickening	8	5.7
Halo sign	19	13.5
Reverse halo sign	4	2.8

Table 5: distribution between severity of infection with chronicand non-chronic disease.

		severity of infection							
		mild		moderate		sever		Total	
		No	%	No	%	No	%	No	%
Chronic disease	Diabetic	6	4.3%	8	5.7%	18	12.8%	32	22.7%
	Hypertension	5	3.5%	21	14.9%	21	14.9%	47	33.3%
	hypertension & diabetic	7	5.0%	7	5.0%	19	13.5%	33	23.4%
	renal disease	1	0.7%	2	1.4%	5	3.5%	8	5.7%

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Non chronic disease	Negative	11	7.8 %	10	7.1 %	0	0.0 %	21	14.9 %
	Total	30	21.3%	48	34.0 %	63	44.7 %	141	100.0 %

χ^2=29.829df=8 p=0.000

DISCUSSION

Chest CT has very high susceptibility to the detection of COVID-19 in all of the latest researches (15), the characteristic radiological characteristics of the patients must be present in the computed tomography scan of the chest, and utilizing the CT in COVID-19 pandemic era is still minimum. The newest recommendations from American College of Radiology (ACR) have noted through the utilization of the CT as first-line test shouldn't be for the screening and diagnosis of the COVID-19(11) with the non-specific presence of COVID-19 on the CT scan, The main reasons result from the exposure to the radiation and the issues of the Infection managements after using the imaging system. However, with the suitable signs in the admitted symptomatic patients may be used chest CTs In every one of the radiology departments, an enhanced algorithm of CT imaging appears warranted for the optimization of the radiation safety and achieving ALARA dose of radiation.

The medical imaging keeps being one of the main radiation exposure sources in the united states, it has been shown that upward the risk of the malignancies has been increased with the patterns of radiation (12).

One of the largest sources is the dose and amount of computed tomography researches exposure of the imagery. Full efforts for the use of the CT examinations with the decrease in the dose of the radiation without affecting diagnostic precision have been highly significant. According to our study, the low-dose protocol used a tube current setting of 30 mAs, while the normal dose protocol used and automatic current modulation varying from 50-210 mAs. The image quality evaluation was divided into two categories: the diagnostic and related radiological results and the clarity of COVID -19 significant detection.When comparing volume CT dose index(CTDIvol) , which is a popular method to estimate a patient's radiation exposure from a CT procedure and is a standardized measure of the radiation dose output of a CT scanner, it was (21.20mGy) in standard dose CT scan and(3.70mGy) in low dose CT scan calculated automatically by the instrument. This suggests that lowering the current from (50-210) mAs to 30mAs would minimize the chance of radiation exposure to patients by 40 to 58 percent. However, this does not reliably quantify the patient's absorbed dose, which is determined by BM. These findings is agreement with the finding reported by (Tabatabaei et al. 2020b)in Iran.

The fundamental aim of the present work is to determine whether or not it was a protocol for the chest CT 30mAs has been scientifically feasible to embrace as one of the syndromes of COVID-19, which could be requiring several CT images to identify the potential Cases that have been defined as indeterminate (for instance, the RT-PCR negative with the high clinical suspicion or known history of exposure). One of the available routine procedures for worsening of the clinical results over symptoms. The results of this study have shown that there aren't any considerable differences in the diagnosis of COVID-19 infection was confirmed in radiologically lab between the low and the standard dosage of the computed tomography scans, with very good rates of reader agreement. It was shown that the typical findings that have been reported lately, which indicate that the COVID-19 chest CT pneumonia can be accurately evaluated to utilize a low-dosage computed

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tomography protocol (Figures. 1a, b & 2a, b). simultaneously, the final diagnosis CT chest Low dose with the COVID-19 had no impact on some of the 141 patients and also had positive reported screen of the RT-PCR. According to our study, of the overall 243 patients (169 males, 74 females) who had positive RT-PCR, examined by using a CT scan only 141 patients with COVID-19 were confirmed as shown in Tables 1 & 2. Patients' ages ranged between 50 -79 (58± 6). These results showed good agreement with a study by(13) in China. The among the total number of people infected with COVID-19, (71%) 173 patients had chronic diseases, as follows: Diabetes (17.3%) 42, Hypertension (30%) 73, Diabetes and Hypertension Together (20%) 50, and Kidney Diseases (3%) 8. In our study, of the overall 141 patients as shown in Tables 3. Shows the mean volume computed tomography dose index CTDIvol Values in standard- and low-dose groups were 8.95±4.06 and 2.21±0.94 mGy, respectively (P-value < 0.001). The mean DLP values were 316.34±141.33and 72.56±14.93 mGy·cm in standard- and low-dose groups, respectively. The mean effective dose values in standard- and low-dose groups were 6.33±2.83 and 1.45±0.30 mSv, respectively. this finding in agreement with the finding reported by (14). in the current study, of the overall 141 patients as shown in Tables 4. the lesion of GGO is 36.9% in agreement with (15) were found1n 38.3% percent of oursample. regarding lesion, consolidation was 13.5% percent inpatient that disagree with the result of a study in (16) were found 1n 45.6% percent of oursample. The main reason for that is the early diagnosis of COVID-19. Diagnosis at an early stage is a very good opportunity to prevent the progression of general ill-health. . regarding Mixed GGO and consolidation were found in 22.0% percent of our sample, which is different from the findings of (17).This disparity may be explained by the fact that our patients were in later stages of the disease when they presented. regarding lesion of crazy paving in Our research showed a “crazy-paving” change in 5.7% of cases, which is consistent with our findings.(18) reported this result in a late onset of infection (6-12 days), implying that a large number of our patients who present in the late stages of the disease. the vascular thickening in 5.7% of the cases In contrast to (17) who registered vascular thickening in 80% of cases and (19) who found this sign in the majority of cases. This sign was identified in 45.2 % of cases by (20) in different studies, suggesting that this sign had different percentages in different studies. lesion of halo sing showed 13.5% of cases ,was agreement which is similar to a study by (21) 16.5% of patient . regarding lesion of reveres halo sing showed 2.8 % of cases, which is consistent with our findings reported by(18) 2% and (22) 3%. This finding of study, of the overall 141 patients as shown in Tables 5. Show distribution between severity of infection with chronic and non-chronic disease. The high result we show of diabetic 12.8% in sever , the high result for hypertension is 14.9% in moderate &sever, the high result for the hypertension & diabetic is 13.5% in sever , the high result for renal disease is 3.5% in sever , non-chronic disease is high result 7.8% in mild . We conclude from this study that chronic disease is related to the high risk with severity of infection and this is disagreement with reported by (23) in china . This different may be due to sample size.

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