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ORIGINAL ARTICLE

A Comparison of Low Dose with Standard Dose Chest CT Scan in Diagnosis of COVID-19

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ABSTRACT

Aim: Comparison of safety profile of low dose CT scan chest with standard dose CT scan in Covid 19.
Study design: Prospective study
Place and duration of study: Department of Radiology, Benazir Bhutto Hospital, Rawalpindi from -01-09-2020 to 31-03-2021.
Methods After approval from ERB, 45 COVID-19 positive patients diagnosed by PCR, aged 55 years and above were selected. In the prospective study, these patients with normal CXR were advised for same day chest CT scan. Initially, a standard dose of chest CT scan of 150mAs was applied. After assessing the chest signs of Covid on scan, a low-dose CT of 30mAs was performed instantly. A comparison was made to check the diagnostic accuracy of standard-dose and low-dose CT for the identification of features of typical COVID19 pneumonia.
Results: The mean age of patients was 58.27±7.23. An admirable intra-reader agreement was found between low- and standard-dose CT in identifying typical findings of COVID pneumonia (intraclass correlation coefficient [ICC] = 0.98–0.99 with A p value of less than 0.001 of all readers). Mean effective dose values of low and standard dose groups were 1.69±0.38 mSv and 7.21±1.23, correspondingly. Values of absolute cancer risk per mean cumulative effective dose of low & standard dose chest CT examinations were 0.68×10^{-4} and 2.41×10^{-4} respectively.
Conclusions: The low dose CT chest protocol is better than standard dose for the identification of typical COVID-19 pneumonia features in routine practice with substantial decrease in dose of radiation as well as estimated cancer risk.
Keywords: SARS CoV 2, Diagnosis, CT scan, Safety profile

INTRODUCTION

Severe Acute Respiratory Syndrome Coronavirus Disease 19 (SARS- COVID-19) started from the Wuhan city of China in the last month of 2019. This disease spread as a pandemic very speedily and affected 203 nations more than 271 million confirm positive cases and 5.3 million deaths globally, till December 20, 2021[1]. Due to its high transmission, Covid became the biggest pandemic seen in the last 100 years. The modern world faced the worst lockdowns during the various waves of this disease, which bore serious medical, social and financial constraints. In this pandemic, the fast spread and surge in deaths can be prevented by timely detection, appropriate treatment as well as public health measurements[2]. Maintaining the social distancing and sanitizing the hands were the only measures to protect against this disease. The real-time reverse transcriptase polymerase chain reaction (RT-PCR) is considered to be the specific diagnostic test for the detection of coronavirus so far but it has certain limitations including limited availability, great false-negative rate and sometimes a delay in confirming the disease also occur[3]. Moreover, to increase specificity, WHO and disease control centers recommend viral testing for the identification of COVID-19 cases. Although these tests have near-perfect specificity and high analytical sensitivity, test sensitivity in clinical side might be affect severely due to certain variables such as handling of specimen, type of specimen, adequacy of specimen and infection stage of specimen development[4]. Some patients showed false negative results of RT-PCR but CT findings of coronavirus were there, they were finally reported positive after sequential sampling[5].

Computed tomography (CT) scans have thus proved superior to other diagnostic tools in diagnosis of the viral infection[6]. Contrarily, CT abnormalities may preclude positive RT-PCR in symptomatic patients and in asymptomatic patients who consequently tested positive by the gold standard PCR[7]. The X rays of chest has been the benchmark test for diagnosis of chest diseases. However, the X Rays chest has shown to be limited Value in diagnosis of viral pneumonia as far as sensitivity is concerned[8]. On the other hand, chest CT scan is documented as a key tool in identifying severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) pneumonia[9].

The thoracic complications of Covid 19 have widely been recognized on CT scans of chest[10]. The degree and severity of disease have been identified on chest CT scans, which confirms the superiority of CT scan over other screening methods[11,12]. Some studies have validated the significance of CT scans in identifying the prognosis of the disease[13]. CT scans of chest can figure out the fallout of the infection and if done repetitively, they can also determine the efficacy of treatment[14]. In contrary, some other researchers have suggested that the importance of CT for diagnosis and screening is not confirmed[15]. In some instances when there is a lack of RT-PCR kits or availability issue then patients can get advantage of CT radiographs of chest in the identification of pneumonia caused by corona virus as it is readily available, highly sensitive and has less test-to-result time interval. Individuals who get utmost benefit from imaging are those who do not respond to supportive treatment, those with comorbidities, those who are at greater risk for complication and those who represent acute clinical deterioration[16]. This raised the need of CT chest practice throughout the pandemic of COVID-19, which encouraged the apprehension about high exposure of radiation to patients as well as workers of health care department[17].

It has been documented and well established that this ionizing radiation enhances the chance of cancer development, the risk of which increases multifold when the patient has to undergo multiple scans for prognostic purposes, as in Covid-19[18]. Recently a study revealed the effects of low dose chest CT and concluded that it has almost zero deteriorating effects on human DNA in comparison to standard-dose chest CT which leads to chromosomal abnormalities and breakage of DNA double-strand[19]. During this pandemic International Commission of Radiological Protection (ICRP) suggested that ALARA (as low as reasonably achievable) principle should be adopted in routine radiology practice. This was advised in order to limit the exposure of covid patients to unnecessary radiations during the course of

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diagnosis[20]. Some previous studies suggested the effects of low dose CT and showed that low dose chest CT scan with low tube current fallouts trustworthy sensitivity than standard dose CT protocols in the diagnosis of intrathoracic pathologies including lung masses, parenchymal abnormalities and pulmonary nodules. It was demonstrated that low dose (25 or 40mAs) chest CT protocol created good quality diagnostic images. This was helpful for the protection of patients against exposure of radiation[21]. Another study concluded that use of tube current of 50mAs also has reliable diagnostic results, so it can be used in replacement of standard-dose of 150 mAs in daily practice[22].

Recently it was reported that application of low dose and ultra-low dose CT has consistent efficiency in the identification of consolidative opacities in COVID-19 pneumonia cases. They compared conventional as well as low-dose protocol in early phases of disease, because in intermediary and late phases, protocol of low dose CT will produce satisfactory diagnostic image quality[23]. Some non-comparison researches suggested that low dose chest CT scan provides satisfactory diagnostic accuracy in pneumonia of COVID-19[24].

The rationale of minimal dose CT scans in the diagnosis and prognosis of this pandemic has gained scientific validity[25]. To date, statistically advanced study based on comparison of standard and low-dose CT on pulmonary findings of COVID-19 patients has not been established yet.

For this purpose, the study was planned to compare 30-mAs chest CT with 150 mAs. Current prospective study is designed to assess the diagnostic accuracy of low and standard dose chest CT in imaging of COVID-19 patients with normal CXR initially.

The hypothesis of the current study specifies that the protocol of low dose chest CT would have an equivalent diagnostic accuracy as standard protocol for the detection of COVID-19 pneumonia.

MATERIALS AND METHODS

This prospective study was conducted at the Department of Radiology, Benazir Bhutto Hospital, Rawalpindi from 1st September 2020 and 31st March 2021. A total of 45 patients who were 55 years or older and had normal chest X rays, were further sent for a same day CT scan (chest) without contrast. Just because the risk of cancer associated with exposure to ionizing radiations is greater in young people, therefore individuals below 55 years of age were not included in the study. Selected patients were RT-PCR positive for SARS-CoV-2 infection when initial imaging was done for the assessment of severity and extent of COVID-19 pneumonia. The research permission was granted by ethical committee of the institute. After an informed consent from participants, the CT scan (chest) of standard-dose was done, low-dose CT was conducted when characteristic features of COVID-19 pneumonia were recognized on standard protocol. The whole procedure was done instantaneously with the patient unmoved on the table. Eventually, 45 patients were enrolled in current research.

CT chest protocols were established using a 16-detector CT scanner (Philips, MX 16). In supine position, the patient examination was done. Two consecutive helical CT scans were obtained from the base of the neck to the liver dome. The tube current was 150mAs and stable tube voltage was 120kVp which is a standard protocol, after that low protocol of 30mAs was done. From each acquirement raw data, attached slices of thickness of 3-mm were reassembled based on lung construction algorithm. Both protocols had a pitch factor of 1. None of the patient received intravenous contrast material. Corresponding clinician was immediately provided with interpreted CT examination results and then he combined the results for clinical case management decision. These radiologists were not involved in conducting the scans. Results of RT-PCR and CXRs were also hidden from the readers. A 3 point CT finding scale was used to record the existence or absence of characteristic SARS-COV2 pneumonia findings for the evaluation of visibility as well as clarity of typical CT COVID-19 pneumonia findings on CT scan. The 3 point CT scale is labelled as 0, certainly absent; 1, ambiguous; 2, certainly present. Each lobe of the lung was interpreted separately by the readers. Right upper lobe (RUL), left upper lobe (LUL), right lower lobe (RLL), left lower lobe (LLL) and right middle lobe (RML) and assign one score to it. Score of 0 showed no typical lesion of COVID-19 pneumonia or normal lung parenchyma. The reader assigned the score 1 when the finding was indistinct (equivocal). A score of 2 was given when one or more than one characteristic lesion(s) of COVID-19 pneumonia were found in concerned lobe. For all five lobes, the scores were combined to offer a sum of total score that ranged from 0 to 10. All CT images were seen with both mediastinal window and lung window settings where mediastinal window has width, 400 HU; level, 40 HU and lung window has width, 1600 HU; level, −550 HU settings. Any of the following standard characteristic features of Covid 19 was labelled as diagnostic criteria[25]. Multifocal ground glass opacity (GGO) of rounded morphology with or without consolidation or visible intralobular lines (crazy paving), peripheral GGO with or without consolidation or visible intralobular lines (crazy paving) and reverse halo sign or other judgments of consolidating pneumonia. Images of mediastinal window settings were also evaluated by the readers for the assessment of pleural/ pericardial effusion or mediastinal/hilar lymphadenopathy. For statistical analysis, kappa (κ) test was employed for analysis of inter-observer agreement between 3 radiologists for every lobe. Intraclass coefficient correlation (ICC) was calculated in order to study inter-observer agreement via comparison of cumulative score of standard-dose and low-dose. However, Intraobserver agreement among standard and low-dose was evaluated by κ values acquired from each lobe and radiologist. For the evaluation of intraobserver agreement of total lung score among low and standard dose, ICC was used. Values of ICC and κ were interpreted according to literature.[26,27] The κ value between 0.81–1.00 was considered as excellent consensus, value of 0.61–0.80 for good consensus, value of 0.41–0.60 is considered for moderate consensus; 0.21–0.40 for fair consensus and value less than 0.20 indicated poor consensus. ICC higher than 0.90 showed excellent agreement while ICC between 0.75 and 0.90 were considered for good, values in between 0.50 and 0.75 were considered moderate and less than 0.50 showed poor agreement. The a p value of less than 0.05 was considered as statistically significant.

Effective radiation dose and cancer risk estimation It was suggested the calculation for effective dose values (mSv) of chest CT scan examination by multiplying two factors i.e. conversion coefficients (0.016 mSv/mGy·cm) with dose-length product (DLP), where DLP values were obtained from patients' information[28]. This current study measured cancer absolute risks with low and standard-dose CT scan examinations according to the risk model publicized in ICRP Publication[29].

RESULTS

There were 32 males and 13 were females, aged between 55 to 100 years (mean age of 67.13±7.23). The average BMI was 24.57±2.8 kg/m^2. For observers A, B, and C the average total lung scores in low-dose CT scan were 6.48±2.8, 5.40±2.1, and 5.9±3.17, respectively. For observers A, B and C, the total scores in standard-dose CT protocol were 6.32±2.9, 5.38±2.7, and 5.8±3.28, correspondingly. All of the three observers didn't report any normal chest CT or without lung parenchymal abnormalities. κ value was used to estimate the agreement between the three observers for each of the protocol i.e. standard-dose and low-dose in all lobes. Observer consensus for assessing total lung score was evaluated for the standard-dose and low-dose measurements (Table 1). Based on ICC values, there is exceptional inter-observer consensus in both standard-dose and low-dose results, 0.79 and 0.82, correspondingly. Statistical comparison between the observers of standard-dose and low-doses was evaluated by using κ, whereas p values were estimated for each lobe. The maximum

similarity amongst standard-dose and low-dose were seen in RUL, RML and LUL i.e. the κ coefficient varied between 0.92 to 1.00 in the three observers (p<0.01). The lowermost agreement was observed in RLL with a κ value ranging from 0.53 to 0.79 (a p value of< 0.01). Intraobserver consensus among standard and low dose was assessed by using ICC in order to calculate total lung score (Table 2). In the estimation of total lung score among standard-dose and low-dose, all observers had high ICC (0.98–0.99) with a confidence interval which was statistically significant (P values < 0.01).

The mean volume computed tomography dose index (CTDI vol) values in low and standard-dose groups were 3.107±0.78mGy and 13.278±1.35 (P<0.01). The mean of DLP values was 104.748±23.65 and 398.56±88.69mGy·cm in low and standard-dose groups, respectively. The mean effective dose values obtained from the low and standard-dose groups were 1.69±0.38 and 7.21±1.23 mSv, respectively. Absolute cancer risk per mean cumulative effective dose values in low and standard dose CT examinations were $0.68x10^{-4}$ and $2.41x10^{-4}$ respectively (Table 3).

Table 1: agreement amongst the observers for both doses i.e. 30mA and 150mA, for individual lobes and TLS (total lung score)

Dose	Lung lobe	Kappa (κ)	P value for κ	ICC [confidence interval]	P value for ICC
Standard-dose	RUL	0.59	< 0.01	0.81 [0.66–0.91]	< 0.01
	RML	0.48	< 0.01		
	RLL	0.52	< 0.01		
	LUL	0.62	< 0.01		
	LLL	0.69	< 0.01		
Low-dose	RUL	0.57	< 0.01	0.84 [0.70–0.93]	< 0.01
	RML	0.45	< 0.01		
	RLL	0.57	< 0.01		
	LUL	0.52	< 0.01		
	LLL	0.71	< 0.01		

Table 2: Agreement between the observersfor low-dose and standard dose readings of all observers in calculation of individual lobes and TLS (total lung score)

Observer	Lung Lobe	Value of Kappa (κ)	P value (for κ)	Interclass coefficient [confidence interval] for TLS	P value for ICC
Observer A	RUL	0.99	< 0.01	0.98 [0.97–0.99]	< 0.01
	RML	0.93	< 0.01		
	RLL	0.79	< 0.01		
	LUL	0.91	< 0.01		
	LLL	0.96	< 0.01		
Observer B	RUL	1.00	< 0.01	0.98 [0.96–0.99]	< 0.1
	RML	0.91	< 0.01		
	RLL	0.67	< 0.01		
	LUL	1.00	< 0.01		
	LLL	0.90	< 0.01		
Observer C	RUL	0.97	< 0.01	0.99 [0.97–0.99]	< 0.01
	RML	0.98	< 0.01		
	RLL	0.53	< 0.01		
	LUL	0.94	< 0.01		
	LLL	1.00	< 0.01		

Table 3: Statistics related to absolute risk of cancer with regards to dose of radiation emitted from standard-dose and low-dose computed tomography of chest in recognition of thoracic features of COVID-19 (CAR = Cancer Absolute Risk)

Dose	CT dose index (mGy)	Dose Length Product (mGy·cm)	Exchange ratio (mSv/mGy·cm)	Operational dosage (mSv)	CAR (×10−4)
Standard-dose	13.278±1.35	398.56±88.69	0.016	7.21	2.41
Low-dose	3.107±0.78	104.748±23.65	0.016	1.69	0.68

DISCUSSION

The pandemic nature of Covid 19 has necessitated the urge for devising a standard radiologic protocol, with higher safety profile, for diagnosis of chest abnormalities in the patients[10]. As many patients might be missed due to false negative PCR, the application of chest CT scans has gradually gained importance in the pandemic of COVID-19[9]. Despite the availability of vaccination, the disease still bears a threat to the entire world with its variants, delta and omicron being the latest in the series[1]. A multidimensional and rapid action is mandatory to limit the mortality of the disease. The overall impact of Covid-19 on financial and health sector has raised the need for a swift and reliable diagnostic tool to identify the thoracic complications of Covid 19, without compromising the health of the subject by the intensity of radiations[10]. Recent research has shown the high sensitivity of chest CT with the presence of characteristic radiologic features in the identification of COVID-19 pneumonia[11]. Although existing American College of Radiology (ACR) guidelines oppose the use of CT scan as a primary diagnostic tool for Covid diagnosis[15] as general presentation of COVID-19 lesion on computed tomography is linked with harmful radiations which is the major cause of problems associated with infections after using the imaging equipment. The chest CT scans must be employed to the suspected patients of covid 19 with the utmost effort to prevent any potential risk of ionizing radiations, i.e. by using low dose radiation[15]. Ionizing radiations have been identified as cancer risk factor. This is already established that increasing trend of exposure to radioactivity enhances the risk of carcinogenesis[30].

Quantities of radiation in CT studies are among the major determinants of cancers caused by imaging exposure. Despite being a global emergency, research data regarding CT scan imaging in Covid 19 is still under consolidation. No significant data is thus far available to affirm the best CT utilization with low dose of radiation and with consistent diagnostic accuracy[31]. The critical nature of COVID-19 pneumonia requires numerous CT images for the diagnosis of doubtful uncategorized cases such as false negative RT-PCR in the presence of strong clinical indicators or patients with deteriorating clinical signs in the progression of Covid and associated illness with definite history of exposure[30], so this inquiry was aimed to assess whether it is logically suitable to adopt a low dose chest CT scan as a standard for diagnosis of Covid features. Our study showed that the difference wasn't statistically significant in detecting laboratory confirmed COVID-19 pneumonia when standard-dose and the 30mA imaging were compared with otherwise normal radiological findings, with tremendous consensus

ratio between the evaluators. Our study established that newly reported typical features for identification of COVID-19 on CT scan of chest may be measured adequately by using low-dose CT protocol. In the same line, the low-dose CT chest ultimate diagnosis of pneumonia in COVID-19 remained unaffected in all of our 45 patients with established Covid through positive RT-PCR test. This study showed a remarkable success in the diagnostic accuracy of the low dose CT scan alongside a safety index of >70% protection against cancer caused by exposure to radiations. Several previous studies have shown that despite reduced image quality, 30mA CT scans have a similar precision in diagnosis as the standard-dose. It was confirmed in these studies that the chest abnormalities were equally identified by the CT scans conducted at lower dosage[32-34]. An earlier study reported that standard-dose and low-dose have similar proficiency in the diagnosis of chestanomalies[35].

Low-dose proficiency has also been observed in CT pulmonary angiography with equally good results as that in the standard radiations of CT scan[36]. Another study validated that low-dose chest scans of CT scan lung screening has been linked with low mortality due to reduced risk of cancer by radiations, thus increasing the safety profile of the scans[37]. Yet, no recent acknowledged low-dose protocol for routine chest CT has been identified in certain clinical cases such as COVID-19. There is evidence that extensively spread disease on chest radiographs is easier to identify on low-dose CT scans. All detected lesions on CT scans were typical for COVID-19 pneumonia where most commonly involved lobes were RLL and LLL, subsequently the upper lobes, whereas RML was the least involved lobe, as shown in the previous studies[8,9,12]. When the differences between the scoring of standard-dose and low-dose were taken into account, no marked influence was seen on the COVID 19 diagnostic accuracy. This shows that low-dose chest CT scan is 100% sensitive, while the ideal test being the standard-dose. However a greater number of studies are requisite in order to assess more precise sensitivity. Ethical issues are also considered as a challenge in order to obtain two CT scans which are associated with higher radiation exposure in such studies. Occasionally respiratory motion can blur the images during CT scan, therefore it is conducted on breath holding when the patient has inspired deeply.

An additional limitation in our study was the unavailability of a gold standard during the recording of the images which could have accounted for some missed lesions.

CONCLUSION

The difference between the standard and low dose CT scans in identifying the lung lesions of Covid 19 was not statistically significant. Concurrently, there was a marked reduction in cancer risk with low dose protocol. The low dose protocol has a beneficial advantage over standard dose protocol as it has a valid diagnostic ability and lower risk of cancer.

Conflict of interest: Nil

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