Research Article

The study and estimation of absorbed and effective doses of corona patients under CT scan in Isfahan based ID Program

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Abstract

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Since the emergence of the coronavirus and the international community's attention to this virus, researchers and medical staff in hospitals have put approaches and methods for dealing with it and early diagnosis on their agenda. The purpose of this study is to estimate the absorbed and effective doses of patients with COVID-19, which was done during different stages of treatment, including the diagnosis of COVID-19 by CT scan. In this study, one of the methods, the Impact Dose program, has been presented to calculate the absorbed and effective dose of people infected with the COVID-19 virus using CT scans of the respiratory tract. This is an analytical cross-sectional study that was conducted at Isfahan Shariati Hospital. The study included 42 patients with Covid-19, who were selected based on doctor's opinion. The effective and absorbed dose was estimated by using the Impact Dose program, which is based on Monte Carlo. The data were analyzed using SPSS-24 software. The effective d and absorbed doses were reported as 1.67 mSv and 54.30 mGy.cm, respectively. The absorbed and effective doses were found to be higher in women than men. The multiple CT scans of patients for the diagnosis of COVID-19 led to an increase in the absorption dose of the community, and lung sonography was recommended as an alternative method due to its high accuracy and its similarity to CT scans in diagnosing COVID-19.

Keyword

Absorbed dose, Effective dose, COVID-19, Lung CT, Impact dose, Monte Carlo.

I. Introduction

The novel coronavirus (COVID-19) is a highly infectious respiratory illness caused by the SARS-CoV-2 virus. The virus was first identified in Wuhan, China, in December 2019 and has since spread rapidly around the world, leading to a global pandemic. COVID-19 is primarily spread through respiratory droplets when an infected person talks, coughs, or sneezes. The symptoms of COVID-19 can range from mild to severe and can include fever, cough, fatigue, body aches, and difficulty breathing. This virus efficiently involves the respiratory system which is severe in theupper part of the lung and causes lesions inthelower part [1].

The COVID-19 pandemic has highlighted the critical importance of early and accurate diagnosis of the disease. One of the key diagnostic tools for COVID-19 is CT (computed tomography) scanning. CT scanning is a non-invasive imaging test that uses X-rays to produce detailed cross-sectional images of the body. In COVID-19 patients, CT scans can reveal characteristic patterns of ground-glass opacities and consolidation in the lungs, which are indicative of the disease. CT can also detect complications such as pneumonia and acute respiratory distress syndrome (ARDS), which can be life-threatening. While CT scanning is not a definitive diagnostic test for COVID-19, it can be a valuable tool in combination with clinical evaluation and laboratory testing. However, the use of CT scanning for COVID-19 diagnosis must be balanced against the potential risks of radiation exposure and the need to conserve resources during the pandemic. Therefore, it is important to use CT scanning judiciously following established guidelines and protocols to ensure optimal patient care [2,3].

The use of radiation is based on the philosophy of "risks versus benefits". On this basis, a radiological test can only be justified when the benefit for the patient is greater than the risk. Among all the diagnostic imaging methods, CT is responsible for the highest dose of radiation to patients. Considering the risks caused by radiation exposure during the pandemic disease, it seems that the CT scan is not a suitable diagnostic method. Also, repeated use in other stages of treatment will lead to more damage [7].

The COVID-19 pandemic has highlighted the critical importance of rapid and accurate diagnosis of the disease. While laboratory testing remains the gold standard for COVID-19 diagnosis, imaging modalities such as CT scanning have emerged as valuable tools in the fight against the disease. However, the use of CT scanning for COVID-19 diagnosis must be balanced against potential risks, including radiation exposure and the need to conserve resources during the pandemic. Recent reports have suggested that some patients may be receiving higher than necessary doses of radiation during CT scanning for COVID-19 diagnosis, raising concerns about potential long-term health effects. Moreover, CT scanning may also have limited sensitivity and specificity for COVID-19 diagnosis, leading to potential overdiagnosis or underdiagnosis of the disease. Therefore, it is important to use CT scanning judiciously following established guidelines and protocols to ensure optimal patient care while minimizing potential risks. [5].

The patient dose is usually given in terms of absorbed or effective doses. It is important to consider the area where the CT is performed and which organs are exposed to radiation, as well as the amounts of effective and absorbed doses, which are useful values for determining potential radiation harm. Since a patient with coronavirus undergoes CT scans of the chest at several points during the treatment period, the dose received each time depends on the level of involvement of the affected person [6]. Currently, researchers in various fields of science have access to efficient tools to assess strengths and weaknesses. One of these tools is the Monte Carlo method, a computational algorithm that uses random sampling to perform calculations [7].

By referring to patients' files to determine the frequency of CT scans and estimating the amount of effective and absorbed doses for each scan, the Monte Carlo code can be used with the obtained data to predict and estimate the amount of absorbed and effective doses and the associated risks. Various methods are used to calculate the dose, including the use of film, TLD, and software. In this study, the Impact Dose software was used, which is based on

Monte Carlo simulation and was published in Report SR252 in 1993 by NRPB. By entering the radiation and patient conditions, it calculates the dose and the volume and weight index of the dose. The main advantage of using this method of dose calculation is that it is free of cost and easily accessible. [8,9].

In 2021, a study aimed at investigating the increase in absorbed dose in the diagnosis of COVID-19 patients using CT scans, it was found that the use of CT scans for diagnosing COVID-19 can lead to an increase in absorbed dose in patients, potentially causing risks. The study results demonstrated that the absorbed dose in COVID-19 patients who underwent CT scans was higher than the recommended levels. Therefore, optimizing the use of CT scans and reducing the absorbed dose in COVID-19 patients is crucial [10].

This study aims to investigate the absorbed dose of COVID-19 patients in Isfahan province who have undergone CT scans for the diagnosis of the disease and are at risk of receiving high doses of radiation. To determine the absorbed dose, the Impact Dose program has been used, which calculates the dose for each patient by entering the radiation therapy conditions and patient conditions. The purpose of this study is to reduce the risk of radiation-induced injuries.

II. MATERIAL AND METHODS

In this study, the inclusion criteria were patients with COVID-19 who were referred to Shariati Hospital in Isfahan. To obtain the absorbed dose and effective dose, the Impact Dose calculation program, which works based on Monte Carlo simulation was utilized. A total of 42 patients with COVID-19, including 24 women (57.1%) and 18 men (42.9%), were enrolled in the study.

The Impact Dose program calculates the effective dose and absorbed dose based on radiation intensity, type of body tissue, shape, size of the area receiving radiation, and other influencing factors (Figure 1). The program uses mathematical models and complex algorithms to estimate radiation dose resulting from particle impact with materials through Monte Carlo simulation.

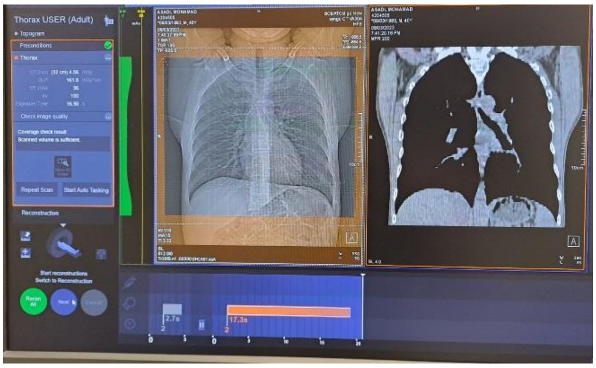

Fig. 1 Impact Dose calculations.

The effective dose is calculated by taking the weighted sum of the dose calculated for all organs, using a sensitivity factor for each tissue, denoted as W(T). The weighted sum of organ doses is represented by H(T) in the formula (1).

$$E = \sum W(T).H(T) \tag{1}$$

The ICRP103 calculation code was used in this study to obtain dose calculation. The calculated quantities, including the dose of main and secondary organs and the effective dose, were displayed in millisieverts. The Kolmogorov-Smirnov test was used to describe the mean, standard deviation, frequency, and percentage of frequency indicators and to check the normality of error distribution in quantitative variables. All analyses were performed in SPSS 24 software with a significance level of 5%.

III. RESULTS

The study findings, including participant characteristics and imaging parameters, are presented in Tables 1 and 2. Patient characteristics, such as gender, age, average anterior-posterior diameter of the body, and average lateral diameter of the body, along with dosimetry parameters, including DLP and $CTDI_{vol}$, are listed in the tables.

Table 1. Demographic factors

Variable	frequency (percentage)
Age	
15-30	6 (14.3)
31-45	7 (16.7)
46-60	19 (45.2)
61>0	10 (23.8)
Sex	
Female	24 (57.1)
Men	18 (42.9)
Number of CT scans	
once	15 (35.7)
twice	17 (40.5)
three times	10 (23.8)

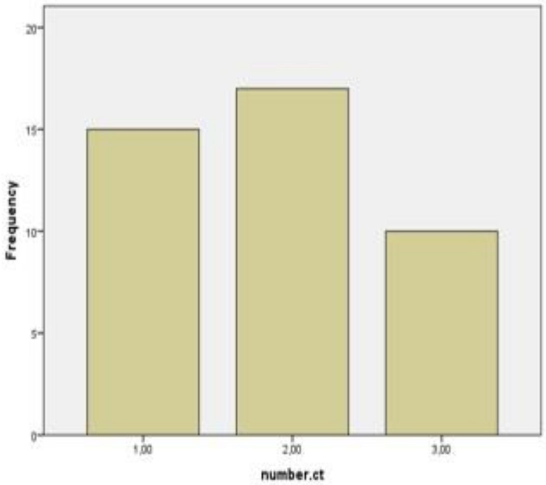

Fig. 2 Chart of the number of CT scans

Fig. 3 Diagram of absorbed dose according to type of gender

Table 2. Demographic factors

	Average	**Max**	**Min**	**std**
Anteroposterior diameter of the body				
Female	27.13	29.31	24.12	1.23
Men	25.58	26.98	24.02	0.84
Lateral diameter of patients' body				
Female	37.88	40.10	36.11	1.35
Man	35.73	39.00	32.22	1.65
$CTDI_{VOL}$	6.06	9.12	3.33	1.46
DLP	80.08	111.00	46.96	18.92

According to Code 103 publications of the International Commission on Radiological Protection, organs are categorized into two groups: main organs and secondary organs. Main organs are those within the radiation field and scanning range that are directly exposed to primary radiation, and include the lungs as a primary organ.

As shown in Table 3, the average absorbed dose in female patients with COVID-19 in the lungs is higher than in men (62.90 vs. 42.84). Additionally, the table shows that the maximum and minimum absorbed doses in COVID-19 patients are higher in women than in men.

Table 3. Absorbed Dose in terms of mGY

Variable	Average desorbed	Maximum desorbed	Minimally desorbed	Sd
All patient	54/30		24/36	18/21
Female	62.90	95.36	32.32	16.97
Men	42.84	69.24	24.36	12.91
P	0.04	0.87	0.63	

Table 4, presents the effective dose values in millisieverts for COVID-19 patients undergoing CT scans. The average effective dose for female patients is higher than for male patients (14.90 vs. 10.18). Additionally, the table shows that the maximum and minimum effective doses for COVID-19 patients are higher in women than in men. The average effective dose for all patients in this study was 16.73.

Table 4. Effective Dose

Variable	Average Effective dose	Maximum Effective dose	Minimum Effective dose	Sd
All patient	1.67	2.73	0.96	0/4
Female	1.81	2.62	0.12	0/3
Men	1.49	2.73	0.96	0/4
P	0.01	0.17	0.03	

IV. DISCUSSION

the radiation dose of CT scans in COVID-19 patients has been a topic of discussion and investigation in the field of diagnosis and treatment of the disease. Recent studies have shown that CT scans are very useful in the diagnosis and follow-up of COVID-19, but they may also increase the radiation dose in patients. Therefore, various investigations have been carried out to detect the spread of COVID-19 while reducing the radiation dose and minimizing the damage to the patient's healthy tissues [11].

In 2020, Ghetti and colleagues conducted a review of radiation cancer risk estimation and high-resolution CT dosimetry of the chest during a COVID-19 outbreak. Using chest CT scan data over two months, they assessed the effective and equivalent dose of organs and the relative risk of lung and other organs. The study concluded that despite the increase in CT scans due to the spread of COVID-19, the estimated cancer risk was very low. Additionally, the study found that the radiation dose received by women was higher than that received by men [12]. Some studies have suggested using low-dose chest CT protocols for COVID-19 patients. Kang et al. implemented a low-dose CT scan protocol that did not significantly sacrifice the signal-to-noise ratio and contrast-to-noise achieved with conventional scanning protocols. Their low-dose protocol provided a DLP of 14.5 mGy cm and an effective dose of 0.203 mSv, which is much lower than the DLP (129.1 mGy cm) and effective dose (1.81 mSv) of the standard chest CT scan protocol [13].

In our study, as reported in the previous section, we found that the effective dose and DLP were 1.67 mSv and 80.08 mGy.cm, respectively. The absorbed dose and effective dose were higher in women than in men, which is consistent with previous studies.

Since most COVID-19 patients require a CT scan, methods to reduce the radiation dose in this test should be found. One solution to this problem is to optimize CT scan parameters. Improving scan images, reducing radiation dose, and thus reducing risks for patients can be beneficial. In addition, using new technologies such as CT scans with lower doses can be a good option for patients. Given the importance of the subject and the increased use of CT scans in COVID-19 patients, it is necessary to find ways to reduce the radiation dose in these tests. Lung CT scans are recommended for early screening of suspected COVID-19 patients, but due to the high volume of CT scan requests, the lack of CT scans in some emergency rooms, the contagiousness of the disease, the risks of transferring sick patients to CT scans, harmful radiation, and high cost, alternative diagnostic methods should be sought. One of the suggested methods is lung sonography, which has a high accuracy similar to CT scans in diagnosing pneumonia [14].

This study was conducted during the outbreak of COVID-19, which may have affected the study results. Another limitation of this study was that it was conducted on only one CT scan machine, so it is recommended to conduct studies on other models of CT scans.

V. CONCLUSION

In this study, the Impact Dose software to calculate the absorbed dose and effective dose used in COVID-19 patients. The results showed that a high dose was administered to the patients, which could be a risk to their health. The average effective dose, absorbed dose, and DLP were reported as 1.67 mSv, 54/30 mGy.cm, and 80.08 mGy.cm, respectively, and the absorbed dose and effective dose were higher in women than in men. Additionally, considering that the amount of radiation dose in lung radiography is 0/1 mSv and in CT is 7 mSv repeated, CT scans for the diagnosis of COVID-19 have greatly increased the absorption dose for patients, so it seems that diagnosing COVID with CT is not a suitable method.

One suggested alternative with high accuracy similar to CT scans in diagnosing pneumonia is lung sonography, which avoids radiation absorption and associated risks and costs.

Other methods to reduce radiation dose include using the low dose methods that are suitable for reducing the dose of inpatients who undergo CT several times during the treatment. Proper planning and personnel training programs can also reduce the possibility of errors in setting imaging system parameters and thus minimize the radiation dose received by patients. In conclusion, using the IMPACT DOSE software and performing dose calculations in COVID-19 patients can be a useful tool to reduce the radiation dose received by patients during treatment.

For future studies, it is suggested that other imaging methods will be investigated to identify patients with COVID-19, and that machine

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