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Comparison of CTDIvol Doses with SSDE in CT SCAN Thorax to COVID and Non-COVID Patients

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ABSTRACT

This study aims to determine the comparison between the radiation dose of computed tomography dose index volume (CTDIvol) and size-specific dose estimate (SSDE) in CT scan thorax for Corona Virus Disease 2019 (Covid-19) and non-Covid-19 patients. The method used in this study is a retrospective study, where the data used is obtained from images of CT Scan thorax examinations of past COVID and non-COVID patients. The amount of data used was 70 for each examination. Furthermore, the CTDIvol and SSDE values were analyzed with IndoseCT software, and then two independent sample T-test statistics were performed with IBM SPSS software. Based on the results of this study, there is a difference between the doses of CTDIvol and SSDE in the thorax CT scan examination of COVID and non-COVID patients. The difference is that the mean CTDIvol dose for COVID patients is 7.90 mGy, and for non-COVID patients is 4.90 mGy, with a p-value of 0.010.

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Meanwhile, at the SSDE dose, the mean for COVID and non-COVID patients was (11.02 ± 1.34) mGy and (7.50 ± 2.77) mGy, respectively, with a p-value of 0.001. Based on these results, it can be concluded that the average dose for COVID patients is greater than that for non-COVID patients; both have a significant difference.

KEY WORDS

CT Scan, Computed Tomography Dose Index (CTDI), Size-Specific Dose Estimation (SSDE), Covid-19, IndoseCT.

Introduction

CT Scan is one of the radiological equipment used to determine and show the anatomical structure of the human body piece by piece [1]. The CT Scan is growing and benefits the medical world, especially for radiodiagnostic [2]. CT Scan has its role in dealing with medical problems recently becoming a world issue, namely COVID-19. To detect and diagnose abnormalities in patients with COVID-19 symptoms, doctors need images of related organs from the patient's body parts [3]. Most COVID patients require imaging of the chest, especially the lungs, so a CT scan of the thorax (chest) is needed. CT Scan of the thorax is one of the medical procedures performed to obtain imaging of specific organs in the thorax. The primary purpose of CT Scan thorax imaging is to find abnormal structures in organs around the chest and help doctors facilitate the detection of disease in patients [4]. The thorax CT scan results in a digital image of the patient [5]. An image with good quality is needed to establish the diagnosis [6]. One of the things related to image quality is the radiation dose given to the patient. The radiation dose must be by the provisions to obtain optimal imaging results. Currently, the amount of radiation dose given to patients in CT scan thorax examination for Covid-confirmed and regular patients is not known, nor is there a difference. The value of the dose given to the risk received by the patient must be considered when a CT Scan is performed. Therefore, knowing the dose for COVID and non-covid patients needs to be done to obtain information that can help reduce the risk received by the patient [7].

One part of the CT scan is the thorax. CT scan of the thorax is performed to obtain a specific picture of the organs in the chest to evaluate the condition of specific organs, such as the lungs or heart, that have suffered injuries or certain diseases. CT scan thorax examination can be done quickly, effectively, and accurately if done by the procedure due to the excellent capability of CT scan [8]. CT scan of the thorax helps doctors detect diseases or abnormalities found in organs in the chest. Thorax CT scan imaging will soon be widely used to detect patients infected with the COVID-19 virus. Doctors can be more assisted in detecting the lung condition of Covid-confirmed patients with CT scan images compared to X-ray images [9]. However, in CT scan thorax examination for both Covid-confirmed and non-Covid patients, the value of radiation dose given to patients is very important to note.

In CT scan examination, several dose rates are used, including volume computed tomography index (CTDIvol) and Size-Specific Dose Estimate (SSDE). CTDI is the dose on a CT scan obtained by integrating the dose profile (D) at one scan divided by the collimation width. After the concept of dose calculation using CTDI was discovered, the standard dosimetry reference changed to CTDI worldwide [10]. CTDIvol is the dose used for helical scanning and is known as the output dose of CT scanners. CTDIvol was originally the result of measurements made on 16 cm and 32 cm PMMA phantoms. SSDE is an estimate of the patient's radiation dose that depends on the diameter of the irradiated organ [11]. Furthermore, the measurement results were inputted into the CT Scan tool as a dose reference. However, as the CT Scan tool develops, the CTDIvol value is the result of a calculation that has been developed and is no longer the result of the initial measurement. Meanwhile, SSDE is the dose value produced after considering the diameter of the patient's body with mGy units, allowing the calculation of the dose received by the patient to be much more accurate [12]. SSDE is an estimate of the patient's radiation dose that depends on the diameter of the irradiated organ [11]. The dose limit the patient receives does not

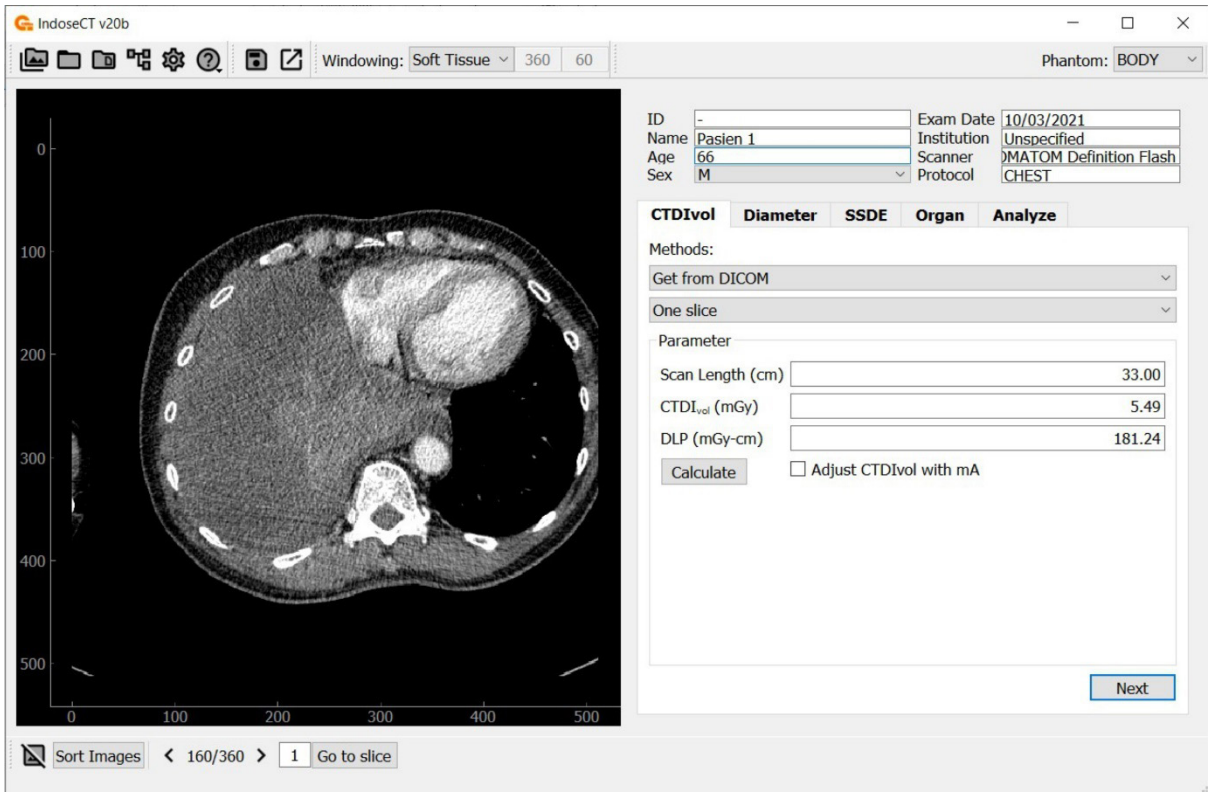

Figure 1. *CTDIvol calculation display*

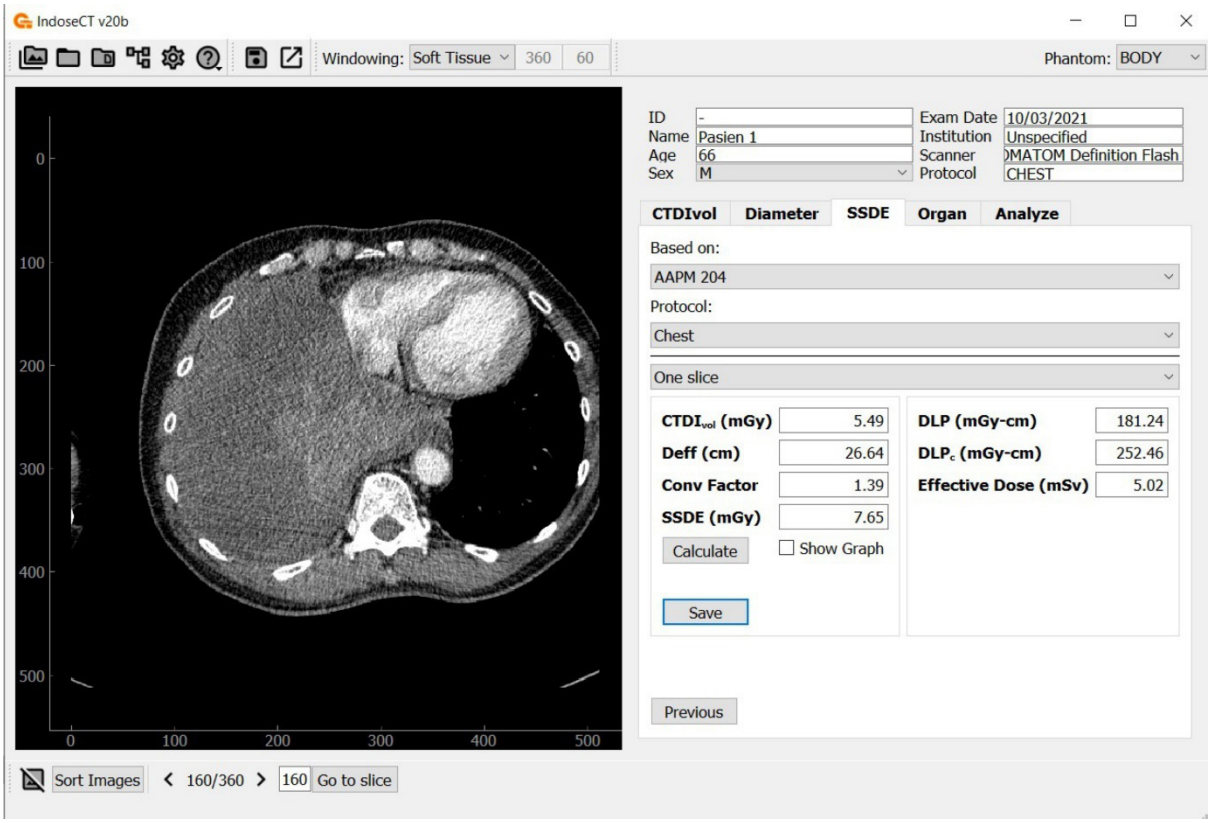

Figure 2. *SSDE calculation view*

Table 1. Calculation results of CTDIvol, water equivalent diameter (Dw), and SSDE dose on IndoseCT software for COVID patients

Criteria	N	Mean	Std
CTDIvol Dose	70	7.90 mGy	1.29 mGy
SSDE Dose	70	11.02 mGy	1.34 mGy
Diameter (Dw)	70	26.46 cm	2.35 cm

have a specific reference stated in the Nuclear Energy Regulatory Agency (BAPETEN) regulations. However, the provision of doses to patients uses the principle of justification, which means that the actions taken must produce benefits greater than losses. Thus, dosing must be done with the minimum possible risk without reducing the quality of the image obtained so that it does not hurt the patient [13]. Especially for CT scan examination of the thorax, the provision of the correct dose by the needs of the patient needs to be considered because, in the thorax, there are essential organs, such as the lungs and heart, which are the center of human breathing and circulation.

An application called IndoseCT has been developed to calculate radiation dose. IndoseCT is a software used to calculate and document patients' radiation dose undergoing CT Scan examination [14]. This study aims to compare the dose used in CT scan thorax examination between Covid and non-Covid patients, both CTDIvol dose and SSDE dose.

Materials and Methods

The subject used in this study is the image of the patient's CT scan examination of the thorax. The data is in images of patient examinations carried out before the research. In this study, the main problem discussed is the analysis of CT Scan radiation dose, either the output dose of the device (CTDIvol) or the radiation scattering dose received directly by the patient (SSDE). The data used are 70 for CT Scan examination of Covid patients and 70 for non-Covid patients, so the total data used is 140. Data collection was carried out using two database software owned by the radiology department of Hasan Sadikin Central General Hospital (RSHS) Bandung, namely Picture Archiving and Communication System (PACS) and Radiology Information System (RIS).

CT Scan thorax examination for COVID and non-covid patients at RSHS Bandung uses different tools. This aims to maintain patient safety from virus transmission. The CT Scan used for COVID patients is located in a particular emergency room isolation room, with the GE Medical Health 32 slice brand. It has been equipped with Tube Current Modulation (TCM). The CT scan used for ordinary patients is located in the radiology department with the Siemens 128 slice brand, also equipped with TCM capabilities. These two different tools cause the calculations in the IndoseCT software to be carried out with different flows. In the Covid patient image, CTDIvol dose information is not stored in the patient image's DICOM info. So that when calculating, the CTDIvol value must be entered manually in the IndoseCT software. However, the CTDIvol dose value is automatically stored in the DICOM info in non-COVID patient images. At the time of data processing in the software, there is no need to enter the dose value manually. In this study, statistical analysis was carried out to obtain the relationship between the dose values of both CTDIvol and SSDE in COVID and non-COVID patients. CTDIvol and SSDE values were analyzed with IndoseCT software, as shown in Figures 1 and 2.

This software can calculate not only the output dose of CT Scan equipment (CTDIvol). However, it can be used to calculate the dose individuals receive in the amount of SSDE [15]. IndoseCT software can determine the amount of radiation dose to patients using patient images. To obtain the SSDE value, the CTDIvol value must be known first. The SSDE value is determined by multiplying the correction factor of the patient's body diameter by the CTDIvol value, which can be obtained based on the output of the CT Scan used for examination. IndoseCT software can also calculate the amount of correction factor in the form of the patient's body diameter, which significantly affects the amount of the patient's SSDE value obtained [16]. Based on the dose

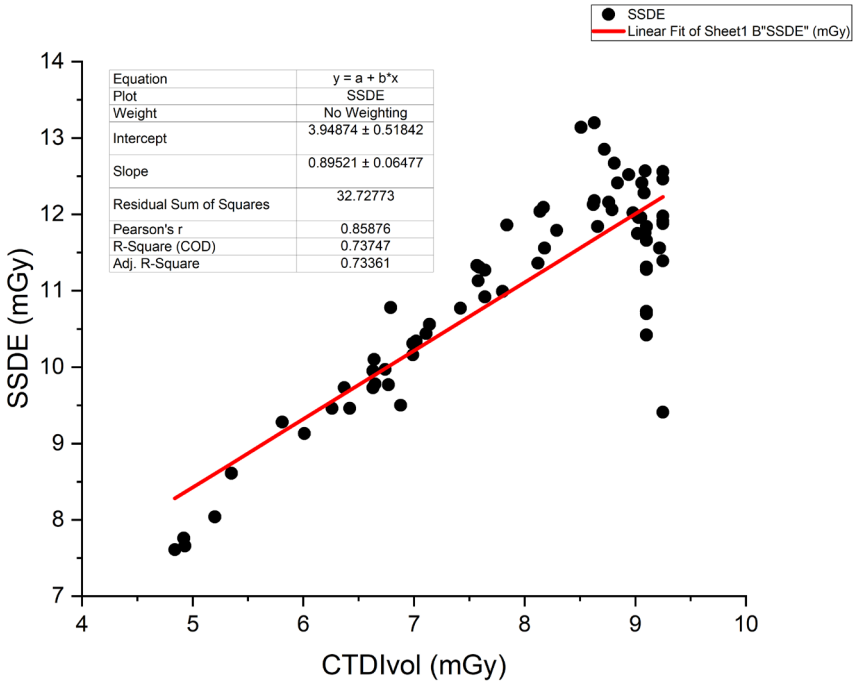

Figure 3. *Data plot between CTDIvol dose and SSDE of Covid patients*

Table 2. CTDIvol calculation results, water equivalent diameter (Dw), and SSDE dose on IndoseCT software for non-Covid patients

Criteria	N	Mean	Std
CTDIvol Dose	70	4.90 mGy	2.11 mGy
SSDE Dose	70	7.50 mGy	2.77 mGy
Diameter (Dw)	70	23.13 cm	3.91 cm

value information obtained from IndoseCT, statistical analysis can determine the relationship between the amount of dose used in COVID and non-COVID patients. Based on the above background, this study will discuss research titled Comparative Analysis of CTDIvol and SSDE in CT Scan Thorax Actions for Covid and Non-Covid Patients.

An application called IndoseCT has been developed to facilitate the calculation of radiation dose. IndoseCT is a software used to calculate and document the radiation dose of patients undergoing CT Scan examination. This software can calculate the output dose of CT Scan equipment (CTDIvol). However, it can calculate the dose individuals receive in the amount of SSDE [17]. IndoseCT software can determine the amount of radiation dose to patients using patient images. IndoseCT software can not only calculate the CTDIvol dose, which is the output dose of the device, but this software has a more specific ability to calculate the scattering dose received by the patient, commonly called the SSDE dose. To obtain the SSDE value, the CTDIvol value must be known first. The SSDE value is determined by multiplying the correction factor of the patient's body diameter by the CTDIvol value, which can be obtained based on the output of the CT Scan used for examination. IndoseCT software can also calculate the amount of correction factor in the form

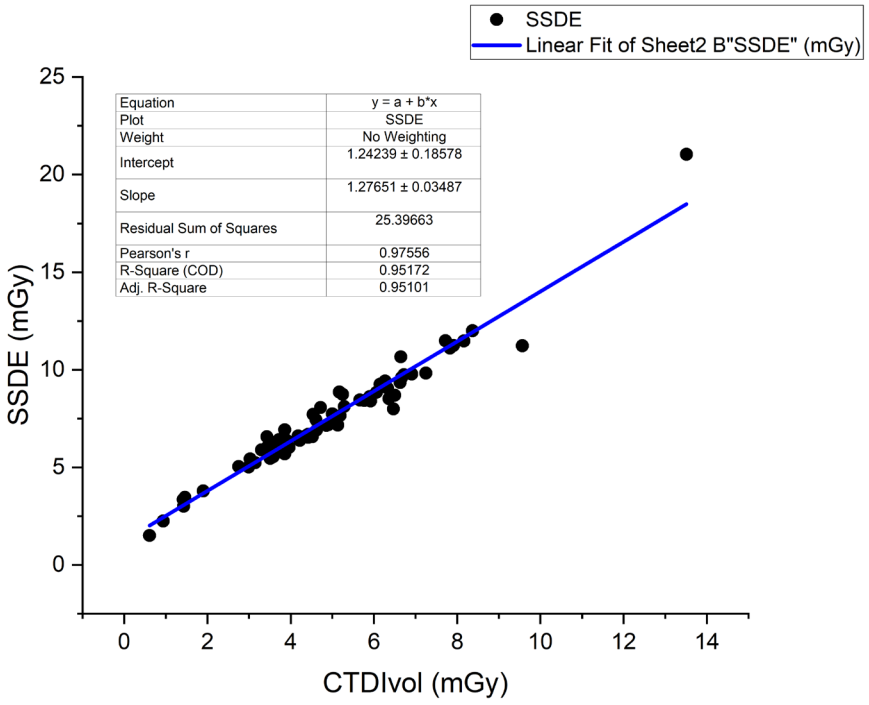

Figure 4. *Plot between CTDIvol dose and SSDE for non Covid patients*

Table 3. T-test results of two independent samples of CTDIvol dose

Patient Group	N	CTDIvol Dose		T-test	
		Mean	SD	Sig.	Conclusion
Covid patients	70	7.90	1.29	0.01	There is a significant difference
Non Covid Patients	70	4.90	2.11		
Total	140				

Table 4. T-test results of two independent samples of SSDE Dose

Patient Group	N	SSDE Dose		T-test	
		Mean	SD	Sig.	Conclusion
Covid patients	70	11.02	1.34	0.00	There is a significant difference
Non Covid Patients	70	7.50	2.77		
Total	140				

https://link.springer.com/article/10.1007/s00411-023-01056-x/tables/2

of the patient's body diameter, which significantly affects the amount of the patient's SSDE value obtained [18]. Based on the dose value information obtained from IndoseCT, statistical analysis can determine the relationship between the amount of dose used in COVID and non-COVID patients.

Then, statistical analysis was carried out using IBM SPSS using a two-independent sample T-test on CTDIvol dose and SSDE value, which aims to determine the difference between the means of two samples that are independent of each other (independent) and determine whether there is evidence that the population mean values are statistically significantly different.

Results

The calculation results from the software for COVID-19 patients show several dose quantities, namely CTDIvol, water equivalent diameter (Dw), and SSDE dose, which can be seen in Table 1 and Figure 3. Figure 3 shows the comparison plot of CTDIvol and SSDE values of the Thorax CT Scan examination. Furthermore, from the graph plot, a linearity approach is performed. From the approach, the linearity value for this graph is y = 0.8952x + 3.9492 with the value of R square (R^2) = 0.7374. The result shows that the R^2 value is close to 1, which means a strong influence exists between the CTDIvol dose and SSDE dose. In addition, it also shows that the CTDIvol and SSDE values are directly proportional, meaning that the greater the CTDIvol value, the higher the SSDE value and vice versa.

For non-Covid patients the results can be seen in Table 2 and Figure 4. Figure 4 compares CTDIvol and SSDE values of the Thorax CT scan examination. The plot of CTDIvol and SSDE dose comparison also uses a linear approach. From this approach, the linearity value for this graph is y=1.2766x+1.2417 with the value of R^2 = 0.9517. These results show that the R^2 value is close to 1 and is included in the strong category. This means a strong influence exists between the CTDIvol and SSDE doses. In addition, it also shows that the CTDIvol and SSDE values are directly proportional, meaning that the greater the CTDIvol value, the higher the SSDE value and vice versa.

The results of these two independent sample T-tests, as presented in Table 3, show differences in CTDIvol doses between Covid and non-Covid patients. This difference is reinforced by the results of the T-test significance of two free samples, which shows a p-value of 0.01, meaning that the $p < \alpha$ ($\alpha = 0.05$). Based on this significance value, it can be concluded that there is a significant difference between the CTDIvol dose of COVID-19 and non-COVID-19 patients.

Based on the results of the T-test of two independent samples, as in Table 4, there is a difference in SSDE dose between Covid patients and non-Covid patients. The difference is reinforced by the results of the T-test significance of two independent samples, which shows a p-value of 0.00, meaning that the $p < \alpha$ ($\alpha = 0.05$). Based on the significance value, it can be concluded that there is a significant difference between the SSDE dose of Covid and non-Covid patients.

From the comparison test that has been carried out, the mean CTDIvol value for Covid patients is (7.90 ± 1.29) mGy, and for non-covid patients, it is (4.90 ± 2.11) mGy with p = 0.01. As for the SSDE dose, the mean for Covid and non-covid patients was (11.02 ± 1.34) mGy and (7.50 ± 2.77) mGy, respectively, with p = 0.00.

Discussion

In its development, CT Scan has several known dose rates, including CTDI and SSDE. These two doses are interrelated in CT scans. This study is based on calculations carried out using IndoseCT software, the CTDIvol dose value and SSDE dose from both examinations, namely Covid and non-covid patients. Several values arise from the IndoseCT software analysis, including the water equivalent diameter or Dw, CTDIvol dose, and SSDE dose. All of these parameters influence each other. For the CTDIvol dose, the influence of the difference in dose value with the patient's body diameter can be caused by the ability of the device to adjust the current to the difference in the scanned body parts (TCM technique) so that the CTDIvol dose value that appears also varies according to the tissue structure and thickness of the patient's body or can also be related to the water equivalent diameter of each patient.

Based on research conducted by Anam *et al.* (2018), it is stated that the use of TCM techniques affects the dose of CTDIvol and SSDE. The diameter of the water equivalent is also related to the size of the current during the TCM technique. It is explained that if the diameter of the patient's body is getting bigger, the working current will increase, and vice versa. If the patient's diameter is small, the working current decreases [19]. So, the diameter and current in TCM are directly proportional. In addition, the current also affects the output dose of the CT Scan tool (CTDIvol); the higher the current that works during the injection, the higher the output dose of the tool will also follow. Thus, the CTDIvol dose in the TCM technique fluctuates with the current. Then, this CTDIvol dose also affects the dose received by the patient's body (SSDE). Based on the explanation, it can be related to the research result that the water

equivalent diameter of the thorax CT scan examination patient affects the dose of CTDIvol and SSDE.

The plot between CTDIvol dose and SSDE dose in each examination resulted in an R^2>0.67, both for COVID and non-COVID examinations. This value indicates that the relationship is in a strong category. The linearity value on the CTDIvol and SSDE dose plots also shows that both values are directly proportional, meaning that the higher the value of one dose, the more the other dose also increases, and vice versa. Comparison between CTDIvol and SSDE doses for each examination was performed by statistical analysis using IBM SPSS. The test results showed that the data were normally distributed, and then the two independent samples T-test could be performed. The statistical test results show a significant difference between the CTDIvol and SSDE doses for COVID-19 and non-COVID-19 patients.

This difference can occur because, in COVID patients, the water composition in the chest area is more than in regular patients, so the dose given will adjust to the patient's body composition [20]. In addition, differences can also occur because the data in this study were obtained from two different tools. The ability of a better tool can cause the patient's dose to be different from a more straightforward tool. Another factor that must be considered regarding the difference in dose is that in this study, the data from the relevant hospitals did not indicate whether the exposure factor used by the operator during suturing was the same between COVID and non-COVID patients. The possible causes of this dose difference should be further observed for further research so as not to cause errors.

In the research of Steuwe *et al.* (2020), who conducted CT Scan Thorax dose optimization for COVID-19 diagnosis, the CTDIvol value was 2.8 mGy, and SSDE was 3.4 mGy. The results of this study are smaller than the results of our study. This study was conducted with a different protocol [21]. Research by Shurche *et al.* (2023) reported that the CTDIvol and SSDE values received by COVID-19 patients were 4.97 mGy and 11.97 mGy, respectively. However, the CTDIvol value in that study was smaller than the CTDIvol in this study. Meanwhile, the SSDE value in this study is smaller than the SSDE in that study [22].

Conclusion

Based on the study's results, it can be concluded that the average dose for COVID patients is greater than that for non-COVID patients; both have a significant difference. The possible causes of this dose difference should be further observed for future research. **R**

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