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Low cancer risk by implementing low-dose chest computed tomography protocol during Covid-19 outbreak

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► ***Short report***

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ABSTRACT

Background: The aim of this study was to evaluate the radiation dose effect of a low-dose chest computed tomography (CT) protocol implemented in our hospital during the outbreak of Coronavirus disease 2019 (COVID-19) by estimating lifetime attributable risk (LAR). ***Materials and Methods:*** A total of 583 patients were randomly included in this study. The values of volumetric CT dose index (CTDIvol, mGy) and dose length product (DLP, mGy.cm) were extracted from CT console. CT-Expo is a CT dose software that was used to estimate effective dose (E) and organ doses. Lifetime attributed risk (LAR) of cancer incidence were calculated according to the Biological Effects of Ionizing Radiation (BEIR) VII report. ***Results:*** Of the 583 patients included in this study, 262 (44.9%) were men and 321 (55.1%) were women. The third quartile of CTDIvol and DLP were 2.5 mGy and 79.4 mGy.cm, respectively. The mean value of E was 1.1 ± 0.3 mSv, and it was statistically higher in females. Esophagus, lung and thymus received highest doses, and also in females breast received highest dose. The mean LAR of lung cancer was 5.3 per 100,000 patients, while the mean LAR of liver cancer was 0.1 per 100,000 patients. ***Conclusions:*** Despite the large number of chest CT scans during the Covid-19 era, the low-dose chest CT protocol implemented in our hospital caused low doses to organs and very low cancer risks.

INTRODUCTION

Coronavirus disease 2019 (Covid-19), which emerged in 2019, is caused by a novel coronavirus and has become a global pandemic affecting numerous countries [1]. To diagnose this disease, respiratory tract samples are collected and analyzed using a method called reverse transcription polymerase chain reaction (RT-PCR), which boasts a sensitivity of approximately seventy-one percent [2].

Computed tomography (CT) scans of the chest have been found to be a dependable method for the early evaluation, staging, and planning of treatment for patients with Covid-19 [3]. Follow up of pulmonary involvement in severe cases requires repeated CT scan in a short interval [4].

Ionizing radiation can have two types of effects: deterministic effects and stochastic effects. Deterministic effects have a specific threshold dose, and if an organ receives this dose, its function will be impaired. Stochastic effects, on the other hand, have no threshold dose, meaning that even low doses of radiation can cause these effects, including cancer and hereditary effects [5].

CT scans do not have the ability to cause deterministic effects from radiation exposure, but they can potentially result in stochastic effects. Therefore, it is important to evaluate the potential risks of radiation due to the significant increase in the number of chest CT exams during the Covid-19 pandemic.

Brenner estimated that low-dose lung CT scans for cancer screening could increase the risk of developing lung cancer by 1 to 6 cases per 10,000 individuals [6]. Another study found that among non-smokers, the risk of dying from lung cancer due to yearly CT screening was estimated to be between 1 and 3 cases per 10,000 individuals [7]. A study during the Covid-19 pandemic found that high-resolution thorax CT scans had an average risk of 2.1 cases of solid cancer per 10,000 patients and 0.2 cases of leukemia per 10,000 patients [8].

The motivation behind undertaking this study stems from the fact that different CT scanners and hospitals employ diverse CT protocols, leading to variations in radiation doses experienced by patients. We implemented a low-dose chest CT protocol in our hospital during covid-19 outbreak to reduce patient radiation dose. The aim of this study was to evaluate the radiation dose effect of this low-dose chest CT protocol during the outbreak of Covid-19 by estimating lifetime attributable risk (LAR) in our hospital.

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MATERIALS AND METHODS

The study received ethical approval from our institution's ethics committee (approval ID: IR.GMU.REC.1400.096, approval date: 2021-10-31). Informed consent was not deemed necessary for this study. This study involved a random selection of 583 patients.

CT imaging was performed with a 16 slice CT scanner for all patients. Demographic information was obtained from the picture archiving and communication system (PACS).

Dosimetric data

The parameters of chest CT protocol were as follows; 130 kVp, 5 mm slice thickness, 1.25 pitch, and 16×1.2 collimation. It should be noted that CARE Dose 4D automatic exposure control was on for all patients with the effective mAs of 25.

The values of volumetric CT dose index ($CTDI_{vol}$, mGy) and dose length product (DLP, mGy.cm) were extracted from dose report page. The third quartiles of these parameters were calculated for diagnostic reference level (DRL) in order to compare with other studies.

CT-Expo (version 2.2) is a software designed for CT dose estimation. It is capable of determining effective dose (E) and organ doses by considering individual factors such as scan range, tube potential, tube current, rotation time, and collimation. By utilizing tissue weighting factors from the international commission on Radiological protection (ICRP) 103, CT-Expo can calculate age-specific and gender-specific patient dose values for both E and organ doses [(9)].

The calculation of organ doses was conducted for various body parts, which encompassed the thyroid, breast, esophagus, lung, liver, stomach, bone marrow, thymus, spleen, and heart.

Estimation of cancer risk

The Biological Effects of Ionizing Radiation (BEIR) VII report was used to determine the LAR of developing cancers [(10)]. This report considers organ dose, patient gender and age to estimate cancer risk.

LARs were computed for various body parts such as the thyroid, breast, liver, lung, and stomach.

Statistical analysis

The mean and standard deviation were used to express the values, and the third quartiles of CTDIvol and DLP were also calculated. The normality of the data was tested using the Kolmogorov-Smirnov test, with a significance level (P value) set at 0.05. To compare between the two groups, the Mann-Whitney test was employed.

RESULTS

This study included 583 patients who were randomly selected. Among them, 44.9% were men and 55.1% were women. The average age of the patients was 57.3 ± 18.6 years.

The mean values of $CTDI_{vol}$, DLP and E were 2.1 ± 0.6, 67.4 ± 21.5 and 1.1 ± 0.3, respectively. Also, the 3rd quartile of $CTDI_{vol}$ and DLP were 2.5 and 79.4, respectively.

Also, we calculated the mean values of $CTDI_{vol}$, DLP and E in terms of gender. On average, the $CTDI_{vol}$ values for females and males were 2.1 ± 0.7 and 2.2 ± 0.6, respectively. The DLP values were 63 ± 19.1 for females and 72.9 ± 23.1 for males. The E values were 1.2 ± 0.4 for females and 0.9 ± 0.2 for males. Whereas DLP was statistically higher in males, E was statistically higher in females ($P < 0.05$). There was no statistically significant difference in $CTDI_{vol}$ between females and males ($P > 0.05$).

Figure 1 shows the organ doses (mSv) in chest CT scan. Organ doses of thyroid, esophagus, lung, liver, stomach, bone marrow, thymus, spleen and heart were 2.3 ± 0.7, 2.9 ± 0.9, 2.9 ± 0.9, 0.8 ± 0.3, 0.5 ± 0.1, 0.7 ± 0.2, 2.9 ± 0.9, 0.6 ± 0.3 and 2.5 ± 0.8, respectively. Also, the breast dose in female was 3.0 ± 1.0 mSv.

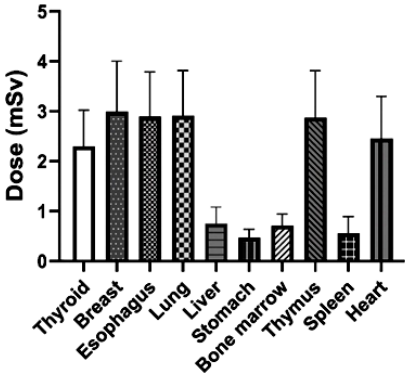

Figure 1. Results of organ doses (mSv) in a chest CT scan for various organs.

Table 1 presents the results of organ doses (mSv) in chest CT scan for females and males. The results show that there is no statistically difference between females and males in terms of organ doses of esophagus, thymus, bone marrow, lung and thyroid ($P > 0.05$). There was statistically difference between females and males in terms of organ doses of spleen, liver, stomach and heart ($P < 0.05$).

Table 1. Comparison of organ doses (mSv) in a chest CT scan for females and males.

Organ	Female	Male	P value
Esophagus	2.85 ± 0.93	2.94 ± 0.84	0.561
Thymus	2.79 ± 1.01	2.94 ± 0.85	0.419
Spleen	0.44 ± 0.14	0.65 ± 0.21	< 0.001
Liver	0.62 ± 0.21	0.86 ± 0.25	< 0.001
Stomach	0.39 ± 0.13	0.60 ± 0.15	< 0.001
Lung	2.80 ± 0.92	2.92 ± 0.80	0.215
Thyroid	2.39 ± 0.80	2.18 ± 0.61	0.186
Heart	2.32 ± 0.86	2.62 ± 0.79	0.042
Bone marrow	0.69 ± 0.24	0.73 ± 0.21	0.286

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Figure 2 illustrates the results of LAR per 100,000 patients due to chest CT scan in COVID-19 patients. For example, the mean LAR of lung cancer was 5.3 per 100,000 patients, while the mean LAR of liver cancer was 0.1 per 100,000 patients.

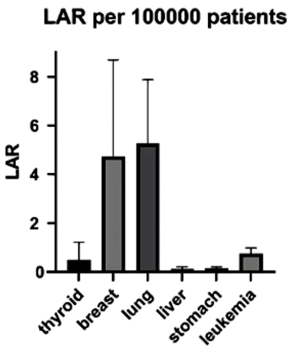

Figure 2. Lifetime attributable risk (LAR) per 100,000 patients due to chest CT scan in COVID-19 patients for various cancer.

Figure 3 compares the results of LAR per 100,000 patients due to chest CT scan in COVID-19 patients between females and males. While the LAR of stomach cancer and leukemia is almost the same for females and males, the LAR of lung cancer and liver cancer is higher in males compared to females. Moreover, the LAR of thyroid cancer is higher in females compared to males.

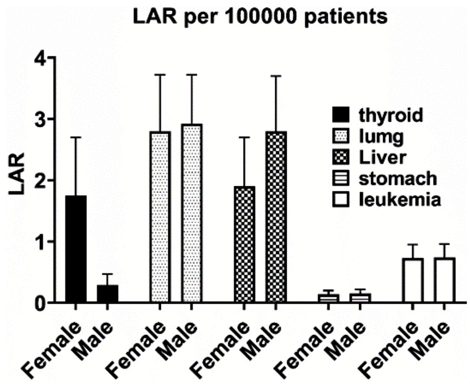

Figure 3. Risk of various cancers per 100,000 patients due to chest CT scan in Covid-19 patients for females and males.

DISCUSSION

In this study we collected dose parameters of chest CT, then calculated effective dose and organ doses with a CT dose software, and finally estimated lifetime attributable risk of cancer.

Our hospital's DRLs for $CTDI_{vol}$ and DLP were 2.5 mGy and 79.4 mGy.cm, respectively. A recent report on national DRLs for chest CT in Iran indicated much higher values of $CTDI_{vol}$ = 12 mGy and DLP = 300 mGy.cm [11]. Furthermore, our DRLs are lower than those set by countries including the UK, Canada, Japan, Egypt, France, Australia, and the United Arab Emirates [12]. In a study similar to ours, Ghetti *et al.* [8] assessed dose parameters and cancer risk during the COVID-19 outbreak in the university hospital of Parma. They reported third quartiles of CTDIvol = 8.0 mGy and DLP = 281 mGy.cm, which are higher than our values.

In this study, we found no statistically difference between females and males in terms of $CTDI_{vol}$, whereas DLP was statistically higher in males. It may be related to different scan ranges in females and men due to their different body length. In line with our results, Ghetti *et al.* [8] reported DLP = 218 mGy.cm for females and 255 mGy.cm for males.

Another important dose quantity is E, which is 1.1 mSv in our study. This quantity was 4.4 mSv in Ghetti *et al.* [8] which may be mainly related to 110 effective mAs compared to 25 effective mAs used in our study. In addition, Tamam *et al.* [13] reported an E of 7.9 mSv in their study, while Lahham et al. [14] observed a E of 7 mSv in their study, both as a result of performing a chest CT scan.

Our result is comparable with Tabatabaei *et al.* [15] study, where reported E = 1.8 mSv with low-dose chest CT (30 mAs). Also, they reported E = 6.6 mSv for standard-dose chest CT (150 mAs). Additionally, we observed that E was statistically higher in females than males, which may be due to higher radiosensitivity of females and is considered by CT-Expo software.

The results of organ doses (mSv) in chest CT scan showed that esophagus, lung and thymus received highest doses. For female also breast received highest dose (3.0 mSv), which is in agreement with Ghetti et al. (9.7 mSv) [8] study, and Tamam *et al.* (10.2 mSv) study [13]. Additionally, Lahham *et al.* [14] documented in their study that there was a considerable average exposure of radiation to the breasts (15 mSv) as a result of chest CT scans conducted in ten hospitals located in the Gaza strip.

In our study, liver received relatively low dose (approximately 0.3 lung dose), whereas in Ghetti *et al.* [8] report, it received relatively high dose (approximately 0.8 lung dose). Moreover, thyroid in our study received higher dose compared to Ghetti et al. report. These discrepancies may be related to different used CT dose software, where Ghetti et al. used Radimetrics software, whereas we used CT-Expo software.

The results showed statistically difference between females and males in terms of organ doses of spleen, liver, stomach and heart. These differences may be related to different phantoms used in CT-Expo software, which uses ADAM phantom for male and EVA phantom for females.

Radiation-induced cancer risks were calculated using BEIR VII report. The model utilized in this report provides an exaggerated estimation of the likelihood of cancer development at the low levels of radiation exposure found in X-ray imaging. Also this model adopts linear-no-threshold (LNT) behavior at low doses (<100 mSv) [10]. The results of LAR due to chest CT scan showed that lung and breast (for female) are at high risk of radiation-induced cancer, which is in good agreement with Ghetti *et al.* [8]

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report.

In this study the mean LAR of leukemia was 0.7 cases per 100, 000 patients, whereas it was 2 cases per 100, 000 in Ghetti *et al.* (8) report. The highest cancer risks were for lung and breast with 5.3 and 4.7 cases per 100,000 patients, respectively, whereas for other organs (thyroid, liver, stomach and leukemia) are less than one case. In addition, Lahhm *et al.* (14) found that for females aged 15-29 years, the average LAR of developing breast cancer was reported as 50 cases among every 100,000 persons. However, for females aged 60-79 years, the LAR was reported as 1 case. These low cancer risks in our study prove the benefit of using low-dose chest CT protocol.

We also investigated the results of LAR due to chest CT scan in COVID-19 patients between females and males. Although there was no significant difference in thyroid dose between females and males, but thyroid cancer risk is remarkably higher in females than males. This is due to that thyroid cancer risk estimate in table 12D-1 of BEIR VII is approximately 5 times higher for female than male. The LAR of liver cancer was higher in male than female, because not only liver dose was statistically higher in male than female, but also liver cancer risk estimate in table 12D-1 of BEIR VII is approximately 2 times higher for male than female.

CONCLUSION

The results of this study showed that cancer risks due to implemented low-dose chest CT scan are low and its diagnostic benefits outweigh its risks. Despite the large number of chest CT scans during the Covid-19 era, the chest CT protocol implemented in our hospital has a very low cancer risk.

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Conflict of interest: There is no conflict of interest.

Ethical considerations: The study received ethical approval from our institution's ethics committee. Informed consent was not deemed necessary for this study.

Author contribution: Two authors were involved in the study's conception and design, data collection, analysis and interpretation of results, and draft manuscript preparation. All authors reviewed the findings and gave their approval for the final version of the manuscript.

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