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Comparison of Radiation Dosimetry of PET/CT and Ct For Lung and Stomach Wall Organs

Zaid Mohammed Safi[1*], Jenan Hussein Taha[1], Mohamed Sadoon Al-Shammaa[2]

[1] Department of Physiology and Medical Physics, College of Medicine, Al-Nahrain University, Baghdad, Iraq
[2] Baghdad Center for Radiation Therapy and Nuclear Medicine, Medical City, Iraqi Ministry of Health, Baghdad, Iraq
Email: zaid801980@gmail.com

***Correspondence author:** Zaid Mohammed (zaid801980@gmail.com)

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Abstract

Background: Positron Emission Tomography (PET) and Computed Tomography (CT) are devices used for diagnosis purposes. One of their helpful uses is in oncology. This study compares the effective dose of PET and CT scans for the lung and stomach wall. Materials and Methods: 50 patients with lung tumors and 50 patients with stomach wall tumors for 100 people. Each patient type's tumors are split evenly in two. There were 25 patients in each of the three groups. A PET scan was used for the first group, whereas a CT scan was used for the second. After an oncologist made a preliminary diagnosis, PET/CT and CT scans were performed on the patients. All PET and CT patients who have fasted for at least six hours have their blood glucose concentration tested before receiving the radiopharmaceutical. Results: The parameters of patients forwarded to CT scan are analyzed, such as the dose of X-ray (mSv), the current used to heat the filament of the x-ray tube (mAs), and the scanning time for the lung and stomach. CT parameters of the brain show higher current (mAs) than the stomach, lung, and thyroid. The effective dose (mSv), scan time (minute), radiation activity (mCi), and SUV (MBq/ml) acquired by the PET scan are shown to have a highly significant difference among the studied organs (lung and stomach). The effective dose is the stomach's highest, followed by the lung. The lung shows to acquire scanning time (minutes) than the stomach. The activity of the x-ray radiation in mCi was found in the stomach, followed by the lung. The stomach standard uptake value (SUV) was higher than the lung. The results of the effective dose of the CT scan compared with the effective dose of the PET scan shows that the effective dose for the CT scan was significantly higher than the PET scan for all the anatomical sites (lung and stomach). The scanning time of the PET scan compared with the CT scan shows that the PET scan is more significant than the time required for the CT scan. The stomach scan requires more examination time than the PET scan w followed by the lung, while in the CT scan, the scanning time of the stomach was higher than the lung. Conclusion: The effective dose obtained from the CT scan is higher than the PET scan for the brain and thyroid.

Keywords

Stomach Wall Organs; healthy; medicienl treatment

PET is a nuclear imaging method that utilizes the distinctive decay properties of radionuclides that decay by positron emission. Produced in a cyclotron, these radionuclides are employed to identify substances of biological relevance. The labeled drug (generally 10^{13}_10^{15} labeled molecules) is administered into the body, commonly by intravenous injection, and its biochemical characteristics define its distribution in tissues (1).

When a radioactive atom on a specific molecule decay, a positron is expelled from the nucleus, resulting in the emission of high-energy photons that have a high likelihood of exiting the body (2).

Fludeoxyglucose is a prescription medication used with Positron Emission Tomography for diagnostic reasons (PET). Fludeoxyglucose may be used alone or in combination with other medicines. Fludeoxyglucose is a member of the Deoxy Sugar

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family of medicines (3). Serious adverse effects of fluorodeoxyglucose include hives, itching, rash, trouble breathing, and swelling of the face, lips, tongue, or neck.

Computed tomography (CT) is a method for capturing images in three dimensions using X-rays. Cross-sectional body scans are produced by taking many flat X-ray images and statistically processing them in a CT scanner. Complementing nuclear imaging well, CT scanners may provide low-noise, high-resolution, anatomically precise images. This has led to the development of PET-CT and SPECT-CT hybrid imaging modalities in the nuclear medicine clinic, requiring knowledge of X-ray and CT scanners from nuclear medicine specialists (4).

Lung cancer is among the most prevalent and deadly forms of cancer. In the United Kingdom, around 47,000 individuals are diagnosed with the illness annually. There are generally no indications of lung cancer in its early stages, but many patients later develop symptoms such as a chronic cough, coughing up blood, persistent dyspnea, unexplained fatigue and weight loss, and an ache or discomfort while breathing or coughing (5)

Primary lung cancer refers to lung-originating lung cancer. Secondary lung cancer is cancer that has spread to the lungs from another area of the body. This page is about primary lung cancer. There are two principal types of lung cancer. These are categorized by the sort of cells from which cancer originates. More than 87 percent of cases are non-small-cell lung cancer, the most prevalent. Lung cancer may be one of three: squamous cell carcinoma, adenocarcinoma or large-cell carcinoma, or small-cell lung cancer. This rare variety often spreads more rapidly than non-small-cell lung cancer (6).

Stomach cancer, also known as gastric cancer, develops from cells in the stomach's lining. As cancer spreads, they spread even more into the stomach wall. The United States is an outlier in terms of its prevalence. The early stages of stomach cancer usually manifest the typical signs such as weight loss or abdominal discomfort associated with the disease. Stomach cancer, also known as gastric cancer, is the uncontrolled growth of cancer cells in the stomach. Cancer may develop anywhere throughout the stomach. Most occurrences of stomach cancer in the United States involve abnormal cell development where the stomach joins the esophagus (gastroesophageal junction). Cancer of the stomach often begins in the upper part of the stomach, especially in high-risk regions. Stomach cancer usually starts in the lining and progresses slowly (95% of the time). If not treated, it may grow into the surrounding stomach tissue, causing a tumor. Cancer can metastasize to other organs in the body (56).

The present study uses patient-specific data dose estimation techniques to characterize and compare body PET and CT scan devices' radiation dosimetry types of specific organs (lung and stomach wall).

Materials and Methods

We conducted retrospective research in the PET/CT department of the Baghdad Center for Radiation Therapy and Nuclear Medicine in the Medical City, Baghdad, Iraq. From the beginning of 2022 through the middle of 2022, statistics were collected. This research was given the go-light by the Al- Nahrain University School of Medicine's Institutional Review Board (IRB). Fifty patients with lung tumors and fifty individuals with stomach wall tumors made up the 100 participants in this research. The tumors of each patient category are split in half. There were 25 patients in each of the three groups. One group performed a PET scan, while the other was given a CT scan. The patients had been given a preliminary oncologist diagnosis before being referred for PET/CT and CT screening. Patients undergoing PET and CT who have fasted for at least six hours have their blood glucose levels checked before receiving the radiopharmaceutical.

PET/CT imaging was performed using General Electric (GE) scanners after an uptake time of around 60 minutes. CT images acquired from patients using the GE Lightspeed 16 CT scanner in the Discovery 690 DSTE PET/CT were utilized to compile the data for this investigation (GE Healthcare, Milwaukee, Wis). The manufacturer's program considered the effects of dispersion, random occurrences, and dead time losses on the emission data. We utilized a 128 by 128 grid of 4.25 mm squared image pixels. The default setting of two iterative reconstruction rounds employing 28 subsets was used to recreate this data. The next step was a PET scan, which covered the whole body from head to thighs and required two minutes for each bed position. PET data were recreated iteratively using the low-dose CT datasets and an ordered subset expectation maximization approach to account for attenuation.

Here are some of the parameters of the PET sets: the average duration between FDG-18 injection and the picture acquisition is 45 minutes, and the kind of image is a Static emission image. The volume of a voxel was calculated to be 30 by 6.3 by 6.3 millimeters. Various scanning settings may be handled with the same reconstruction algorithms, producing reliable picture data each time. To convert image intensity measurements, the Standardized uptake values of SUV units are employed.

This study used a CT scanner, model number

Toshiba AQUILIONE CGGT-021A, with 64 slices. We've got the CT gantry rotating at 0.8 s and the table moving at 30 mm each gantry revolution. Transaxial CT images with a thickness of 5 mm were reconstructed at a resolution of 4.25 mm (trans axial). The CT settings are as follows: Helical-Axial imaging is used for low-dose CT scans. The voxel size is 3.27 mm X 1.37 mm X 1.37 mm (in mm^3). The tube is configured to operate at 240 KVp and 440 mA. The cutting-edge CT reconstruction algorithms overcome technological obstacles associated with cone-beam and high-pitch helical scanning for Hyperplane and Crossbeam, which provide artifact-free pictures and optimum slice profiles at any pitch. The Hounsfield scale was used to convert the intensity of the images (HU).

SPSS-25, a well-used statistical program, was used for the data analysis (Statistical Package for Social Science-version 25). For this study, we used a paired t-test to determine whether there was a statistically significant change in the dependent mean (the quantitative data). A p-value of 0.05 or below was judged statistically significant.

Results

Parameters of CT scan

The parameters of patients forwarded to CT scan are analyzed, such as the dose of X-ray (mSv), the current used to heat the filament of x-ray tube (mAs), the scanning time for the overall sites, and each anatomical organ included in this study. The organs are the lung and stomach walls. The results of CT parameters are shown in table (1). The stomach wall shows a higher effective dose and time than the lung. The current (mAs) for the lung was higher than the stomach wall.

Table (1): The Parameters of CT Scan.

Anatomical Site	Effective Dose (mSv)	mAs	Scan Time (Minute)
Lung	1.71 ± 0.21	126.68 ± 37. 44	1.54 ± 0.08
Stomach	1.76 ± 0.23	123.24 ± 43.81	1.63 ± 0.012
p-value	0.741121	0.646442	< 0.00001*
* Significant Difference at p-value level ≤ 0.05.			

Parameters of PET Scan

The statistical results of the effective dose (mSv), scan time (minute), radiation activity (mCi), and SUV (MBq/ml) acquired by the PET scan are illustrated in the table (2). All these parameters are shown a highly significant difference between the lung and stomach walls. The effective dose is higher in the stomach than in the lung. The lung shows to acquire scanning time (minutes) than the stomach. The activity of the x-ray radiation in mCi was found in the stomach, followed by the lung. The stomach's standard uptake value (SUV) was higher than the lung.

Table (2): The Parameters of PET Scan.

Anatomical Site	Effective Dose (mSv)	Scan Time (Minute)	Radiation Activity (mCi)	SUV (MBq/ml)
Lung	0.54 ± 0.08	17.98 ± 0.29	10.39 ± 0.49	0.065 ± 0.0033
Stomach	0.63 ± 0.012	16.93 ± 0.74	11.29 ± 3.99	0.158 ± 0.018
p-value	< 0.001*	0.04321*	< 0.01*	< 0.001*

Comparison Between the CT scan and PET scan

The results of the CT scan's effective dose compared with the PET scan's effective dose for the lung and stomach are presented in table (3). The effective dose for the CT scan was significantly higher than the PET scan for all the anatomical sites (lung and stomach)

Table (3): Comparison of the Effective Dose (mSv) Between the CT Scan and PET scan

	CT scan	PET Scan	p-value
Lung (mSv)	1.71 ± 0.21	0.54 ± 0.08	< 0.00001*
Stomach (mSv)	1.76 ± 0.23	0.63 ± 0.012	< 0.00001*

The scanning time of the PET scan compared with the CT scan is shown in table (4). The examination time of a PET scan is highly significant than the time required for the CT scan. The stomach scan requires more examination time than the lung in CT and PET scans.

Table (4): Comparison of the Time (minute) Between the CT scan and PET scan

Anatomical Sites	CT scan	PET Scan	p-value
Lung (minute)	0.54 ± 0.08	15.98 ± 0.29	< 0.00001*
Stomach (minute)	0.63 ± 0.012	17.93 ± 0.74	< 0.00001*

Discussion

Khursheed et al. surveyed CT scans in multiple centers for adult patients. They found that the effective dose (mSv) for adults was one mSv (7). The total effective dose of this study (PET and CT) is subtracted from the recommended effective dose to calculate the difference. The results show that this study's effective dose is below the threshold, which means it is safe for patients. The PET scan results were within limits for the lung and stomach wall. While the CT scan results were above the lung (0.71 ± 0.21 mSv), and stomach wall (0.76 ± 0.23 mSv)

The risk posed by radiation Exposure to the patient is vital to protocol optimization and staff protection and is essential for risk/benefit evaluations. The dosages used for risk estimate may be used to characterize a clinic's patient population and image capture procedures. Dose estimation strategies may incorporate universal normative values and individual patient and scanner details. Many cancer patients may need many scans, and their cumulative radiation exposure must be monitored; therefore, an accurate forecast of patient dosage is far more important than a conservatively high estimate (8).

The data of patients in this research, as in table 1, referred for a CT scan are evaluated, including the X-ray dosage (mSv), the current utilized to heat the filament of the x-ray tube (mAs), and the scanning duration for the overall sites, and each anatomical organ included in this research. The organs are the stomach and lungs. The stomach current (mAs) is greater than that of the lungs. The effective dosage (mSv) and scanning time for the stomach and lungs were determined.

In that order, we found that the stomach received the largest effective dosage of x-rays, followed by the lungs. The stomach required the longest scanning time (in minutes), followed by the lungs.

This study made use of the statistical findings of PET on the effective dose (mSv), scan time (minutes), radiation activity (mCi), and SUV (MBq/ml) collected by the PET scan, table 2. All these measures are substantially different across the three organs evaluated (lung and stomach). The stomach seems to have the largest effective dosage, followed by the lung. The lung seems to have more scanning time (minutes) than the stomach. The stomach wall was the organ with the highest x-ray radiation activity, measured in mCi. The lung followed this. The stomach standard uptake value (SUV) was greater than the lungs.

Several publications have published research on the absorbed dose of 18FDG to different organs based on the kinetics of FDG-18 distribution in humans (9−13). Several experiments were conducted based on the kinetics of FDG-18 distribution in humans. For internal dosimetry estimates for both sexes, data on the kinetics of 18FDG distribution in humans are necessary from a very limited number of investigations. Since these computations are required for medical imaging, this is an issue. There is just one study conducted by Niven et al.(9) study 18 that compared the amount of time FDG-18 stayed in the brain and the amount of radiation it got from male and female patients and found substantial differences between the genders.

When compared across all anatomical areas, the effective dosage for the CT scan was much greater than that of the PET scan (lung and stomach), table 3. Based on the findings of this study, it has been determined that the examination time necessary for a PET scan is much less than the time needed for a CT scan. Regarding CT scans, the time spent scanning the brain is more than that spent scanning the stomach and the lung, table 4. On the other hand, when it comes to PET scans, the amount of time spent scanning the stomach is greater than that spent scanning the lung.

The outcomes of this study show that it is safe for patients to use since the effective dose required is far less than the threshold. The PET scan revealed that the thyroid, lungs, and stomach were all within acceptable limits. The only organ that exceeded normal limits was the brain, which was determined to contain more than one mSv. In contrast to the CT scan results concerning the brain, lungs, and stomach, the thyroid operated within the usual range of parameters.

In a study performed by Kaushik et al. (13), they found no significant difference in the residence time and absorbed dose to male and female organs, brain, and stomach. In addition, they discovered that the proportion of uptake in male brains was greater than that of female brains and that the amount of time spent in male brains was somewhat longer than that spent in female brains. Both differences were seen. On the other hand, for a given quantity of activity delivered, the overall dosage given to the female brain was somewhat larger than the dose given to the male brain. Furthermore, they declare that it was found that there was no significant variation in the biodistribution of

FDG-18 between the brains of men and females because there was no significant difference in the residence periods of activity in the brains of males and females. This might be because the people or patients picked for the research were of a different kind, which in turn could influence how quickly the radiopharmaceutical worked in their bodies.

Although Bacher et al. reported that the men and females have comparable biodistribution, females are given a larger dosage for the same activity, owing to a difference in the SUV values (14).

Although the lung does not actively absorb 18F-FDG, our research suggests that this organ receives the third-highest dosage, possibly because of its closeness to the heart. Based on the patient's medical history, we calculated the individual internal dose of 18F-FDG by considering numerous factors, including the injected activity and height.

It's more convenient for the patient if they just have to make one journey to the imaging clinic rather than two. Combining scans might be more convenient for the patient if the doses are equivalent. Compared to a diagnostic PET scan, the radiation exposure from a conventional PET/CT with a separate diagnostic CT may be higher or lower, depending on the clinic's circumstances. At first glance, a PET/CT with a diagnostic technique may appear qualitatively comparable to a standard PET/CT with separately obtained diagnostic CT; however, the diagnostic technique CT in the PET/CT diagnostic technique may also be used for attenuation correction, resulting in a different dosage.

To our knowledge, no previous study compared the effective dose to the patient-generated from the CT and PET scans. So this is the first study spoked on this subject.

Conclusion

Imaging with positron emission tomography (PET) and Computed tomography (CT) is indicated for any oncology lung and Stomach disease. However, the nuclear medicine physician or radiologist interpreting whole-body PET and CT and the referring physician should have a detailed understanding of the characteristics of uptake oncology lung and Stomach tumors. The effective dose obtained from the CT scan is higher than the PET scan. The PET scan is more accurately diagnosed, especially in oncology, but it is more time and money-consuming.

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