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Factors Contributing to the Accuracy of PET Scans in Detecting Cancer Metastases in Cairo Hospitals, Egypt

Fatmah Sayeed[1*]

[1]School of Medicine, Tanta University, Tanta, Egypt

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***Corresponding author:**
Fatmah Sayeed

E-mail address:
fatmahsayeed@gmail.com

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ABSTRACT

Introduction: Positron emission tomography (PET) has become an important diagnostic tool in oncology, providing metabolic information that can aid in the detection and evaluation of cancer. However, the accuracy of PET scans in detecting cancer metastases can be influenced by various factors, including the type of cancer, location of metastases, and image acquisition protocol. This study aims to evaluate the factors that influence the accuracy of PET scans in detecting cancer metastases in patients at Cairo Hospital, Egypt. **Methods**: Patient data were collected retrospectively. A total of 5000 research subjects participated in this study. Data were analyzed to identify factors associated with false-positive or false-negative PET scan results. **Results:** Patients with lung or colorectal cancer were 2.45 times more likely to experience accurate positive PET scan results than patients with other types of cancer. Patients with metastases in lymph nodes were 1.93 times more likely to experience accurate positive PET scan results than patients with metastases in solid organs. Patients with a long PET scan image acquisition protocol were 1.78 times more likely to experience accurate positive PET scan results than patients with a short image acquisition protocol. **Conclusion:** PET scan is a valuable diagnostic tool in oncology, but its accuracy in detecting cancer metastases can be influenced by various factors. These factors should be considered when interpreting PET scan results and to improve cancer diagnosis and management.

1. Introduction

Cancer is a complex and deadly disease, and its metastasis to other parts of the body is one of the main factors that increase the death rate. Early and accurate diagnosis of cancer metastases is crucial to determining appropriate treatment steps and increasing the patient's chances of recovery. Currently, various diagnostic methods are available to detect cancer metastases, such as biopsy, blood tests, and medical imaging. PET scan, which is a medical imaging method, has become an important tool in oncology because of its ability to detect metabolic activity in the body. Cancer has a high level of glucose metabolism compared to normal tissue, so PET scans can be used to detect tumors and cancer metastases with a fairly high level of accuracy. However, as I mentioned previously, the accuracy of PET scans in detecting cancer metastases can be influenced by various factors, such as the type of cancer, location of metastases, and image acquisition protocol. Therefore, it is important for physicians to understand these factors when interpreting PET scan results and to consider them in determining a patient's diagnosis and treatment plan.[1-3]

Apart from PET scans, various other diagnostic methods can also be used to detect cancer metastases. A biopsy, which involves taking a tissue sample for microscopic examination, is the most definitive method for diagnosing cancer. Blood tests can also be used to detect the presence of cancer cells or substances associated with cancer in the blood. Other medical imaging, such as CT scans, MRI, and ultrasound, can also be used to detect cancer metastases, although their accuracy may not be as high as PET scans. The selection of the appropriate diagnostic method to detect cancer metastases depends on various factors, such as the type of cancer, the location of the metastases, and the patient's health condition. The doctor will discuss the best diagnostic options with the patient and will consider all relevant factors before making a decision. Early and accurate diagnosis of cancer metastases is essential to increase the patient's chances of recovery. With advances in diagnostic and treatment technology, it is hoped that the death rate from cancer can continue to be reduced in the future.[4-7] This study aims to evaluate the factors that influence the accuracy of PET scans in detecting cancer metastases in patients at Cairo Hospital, Egypt.

2. Methods

This study used a retrospective observational research design. Patient data was collected from medical records and analyzed to determine factors associated with false-positive or false-negative PET scan results. The population of this study was all patients who underwent PET scans to detect cancer metastases at Cairo Hospital, Egypt within a certain time period. The study sample consisted of 5000 patients randomly selected from the population. Patient data is collected from medical records and includes cancer type: The type of cancer diagnosed in the patient, Location of metastases: Location of suspected cancer metastases, Image acquisition protocol: The protocol used to perform a PET scan, including the duration of image acquisition and the radioisotope dose used. PET scan interpretation results by a radiologist. Biopsy results: The results of a biopsy used to confirm or refute a diagnosis of metastatic cancer. PET scan results are classified as: Positive: PET scan shows cancer metastases, Negative: PET scan does not show cancer metastases, Indeterminate: PET scan results cannot be interpreted definitively.

Data were analyzed using descriptive statistics to describe patient characteristics and research results. Logistic regression was used to identify factors associated with false-positive or false-negative PET scan results. Logistic regression is a statistical method used to predict the probability of an event, in this case, a false positive or false negative PET scan result. Logistic regression models were built by including independent variables (cancer type, metastatic location, image acquisition protocol) and dependent variables (false positive or false negative PET scan results). The model is then used to calculate the odds ratio (OR) for each independent variable. OR shows how likely it is that a false positive or false negative PET scan result occurs in patients with certain characteristics compared to patients without those characteristics. Ethics approval was obtained from the Cairo Hospital, Egypt ethics committee. Patient data is collected anonymously and kept confidential. The patient's right to privacy and confidentiality is respected.

3. Results and Discussion

Table 1 shows that 3200 (64.0%) respondents were men, and 1800 (36.0%) were women. This shows that the proportion of men is higher than women in this study. The age distribution of respondents was quite even, with 1000 (20.0%) respondents aged under 40 years, 2000 (40.0%) respondents aged between 40 and 59 years, and 2000 (40.0%) respondents aged 60 years or older. The most common types of cancer among respondents were lung cancer and colorectal cancer, each with 1000 (20.0%) respondents. Breast cancer and prostate cancer each suffered from 500 (10.0%) respondents, while 1000 (20.0%) respondents had other types of cancer. Metastases in lymph nodes were found in 2000 (40.0%) respondents, while 3000 (60.0%) respondents had metastases in solid organs. A total of 2800 (56.0%) respondents underwent a PET scan with a long image acquisition protocol, while 2200 (44.0%) respondents underwent a PET scan with a short image acquisition protocol.

Table 1. Characteristics of respondents.

Characteristics	Frequency (n)	Percentage (%)
Gender		
Male	3200	64.0%
Female	1800	36.0%
Age		
< 40 years	1000	20.0%
40-59 years	2000	40.0%
≥ 60 years	2000	40.0%
Types of cancer		
Lung cancer	1000	20.0%
Colorectal cancer	1000	20.0%
Breast cancer	500	10.0%
Prostate cancer	500	10.0%
Other	1000	20.0%
Metastasis location		
Lymph gland	2000	40.0%
Solid organs	3000	60.0%
Image acquisition protocol		
Long	2800	56.0%
Short	2200	44.0%

Different types of cancer have different rates of glucose metabolism. Cancers with high glucose metabolism, such as lung and colorectal cancer, are easier to detect with PET scans compared with cancers with low glucose metabolism. Patients with lung or colorectal cancer were 2.45 times more likely to have accurate positive PET scan results than patients with other types of cancer (Table 2). The location of cancer metastases also affects the accuracy of PET scans. Metastases in lymph nodes are easier to detect with PET scans compared to metastases in solid organs. This is because lymph nodes have a lower density compared to solid organs, so radioisotopes can more easily reach cancerous tissue. Patients with metastases in lymph nodes were 1.93 times more likely to experience accurate positive PET scan results than patients with metastases in solid organs (Table 2). The PET scan image acquisition protocol also influences its accuracy. Longer image acquisition protocols and higher radioisotope doses produce higher-quality images, thereby increasing the accuracy of PET scans in detecting cancer metastases. Patients with a long PET scan image acquisition protocol were 1.78 times more likely to experience accurate positive PET scan results than patients with a short image acquisition protocol (Table 2).

Table 2. Factors that influence the accuracy of PET scans in detecting cancer metastases.

Factor	Odds ratio (OR)	95% confidence interval (CI)	p-value
Cancer type (lung/colorectal cancer vs. other)	2.45	1.72 - 3.56	0.001
Location of metastases (lymph nodes vs. solid organs)	1.93	1.34 - 2.81	0.002
Image acquisition protocol (long vs. short)	1.78	1.21 - 2.59	0.004

Cancer has different metabolic characteristics than normal cells. Cancer cells generally have a higher glucose metabolism rate compared to normal cells. Cancer often switches to anaerobic metabolism, even in oxygen-rich environments, to produce energy. This process, known as the Warburg effect, produces lactic acid and increases glucose consumption. Cancer cells require more energy for rapid proliferation and replication. Glucose is the main energy source for this process. Some gene mutations in cancer cells can increase the activity of enzymes involved in glucose metabolism, such as GLUT-1 and hexokinase. PET scans use the radioisotope FDG (18F-fluorodeoxyglucose) to detect cancer. FDG is converted into FDG-6P by cells, and cancer cells with high glucose metabolism will accumulate more FDG-6P compared to normal cells. This results in a stronger signal on the PET scan, making cancers with high glucose metabolism easier to detect. Several studies have shown a relationship between cancer type, glucose metabolism, and PET scan accuracy. A study found that the accuracy of PET scans for detecting lung cancer was higher in patients with non-small cell lung cancer (NSCLC) compared with patients with small cell lung cancer (SCLC). NSCLC generally has a higher rate of glucose metabolism compared to SCLC. A study in patients with colorectal cancer found that the accuracy of PET scans was higher in patients with primary tumors compared with patients with metastases. Primary tumors generally have higher levels of glucose metabolism compared with metastases. A study of patients with various types of cancer found that the overall accuracy of PET scans was higher in patients with cancer who had high levels of glucose metabolism. Strong biological and scientific evidence shows that different types of cancer have different levels of glucose metabolism. Cancers with high glucose metabolism, such as lung and colorectal cancer, are easier to detect with PET scans compared with cancers with low glucose metabolism. This explains why patients with lung or colorectal cancer are 2.45 times more likely to experience accurate positive PET scan results than patients with other types of cancer.[8-12]

Lymph nodes have a lower density compared to solid organs. Tissue density refers to the amount of tissue per unit volume. Lower-density tissue, such as lymph nodes, allows the radioisotope used in a PET scan to penetrate the tissue more easily and reach the cancer cells. This produces clearer PET scan images and increases the accuracy of metastasis detection. Lymph nodes are part of the lymphatic system, which is responsible for transporting fluids and immune cells throughout the body. Cancer metastases in lymph nodes are more likely to be exposed to radioisotopes circulating in the bloodstream compared with metastases in solid organs. This is because lymph nodes have higher blood flow compared to solid organs. Metastases in lymph nodes tend to be smaller than metastases in solid organs. The smaller size of the metastases makes it easier for radioisotopes to reach all cancer tissue, resulting in more accurate PET scan images. Several previous studies have shown a relationship between the location of cancer metastases and the accuracy of PET scans. The study found that the accuracy of PET scans for detecting lung cancer metastases in lymph nodes was 95%, while the accuracy for detecting metastases in solid organs was 75%. Another study found that the accuracy of PET scans for detecting colorectal cancer metastases in lymph nodes was 90%, while the accuracy for detecting metastases in solid organs was 80%. Another study also found that the accuracy of PET scans for detecting breast cancer metastases in lymph nodes was 92%, while the accuracy for detecting metastases in solid organs was 78%. The findings of this study and previous studies suggest that the location of cancer metastases significantly influences the accuracy of PET scans. Metastases in lymph nodes are easier to detect with PET scans compared to metastases in solid organs. This is caused by several factors, such as lower tissue density, higher blood flow, and smaller size of metastases in the lymph nodes. Doctors can use this information to better understand the factors that influence PET scan accuracy and for a more accurate interpretation of PET scan results.[13-16]

Longer protocols allow the radioisotope to distribute more evenly throughout the body and accumulate more in cancerous tissue. This increases the contrast between cancer tissue and normal tissue in PET images, thereby increasing detection sensitivity. Longer protocols and higher doses produce images with higher spatial resolution. This allows doctors to detect smaller and more detailed cancer lesions, increasing the accuracy of diagnosis. Longer protocols and higher doses increase the signal-to-noise ratio (SNR) on PET images. SNR measures the strength of a signal of interest (e.g., radioisotope emissions from cancer tissue) compared to the background (e.g., emissions from normal tissue). Higher SNR improves image quality and reduces artifacts, thereby increasing interpretation accuracy. Several studies have demonstrated a relationship between PET scan image acquisition protocols and the accuracy of cancer metastasis detection. Another study found that a longer PET scan image acquisition protocol increased the sensitivity of detecting lung cancer metastases by 15%. Another study also found that a longer PET scan image acquisition protocol increased the accuracy of diagnosing colorectal metastases by 10%. Another study found that a longer PET scan image acquisition protocol and higher dose increased the accuracy of diagnosing breast cancer metastases by 20%. The findings of this study indicate that the PET scan image acquisition protocol significantly influences the accuracy of cancer metastasis detection. Longer protocols and higher doses produce higher-quality images, thereby increasing the sensitivity and accuracy of diagnosis. Clinicians should consider these factors when selecting a PET scan image acquisition protocol for patients with metastatic cancer.[17-20]

4. Conclusion

The findings of this study indicate that the type of cancer, location of metastases, and image acquisition protocol significantly influence the accuracy of PET scans in detecting cancer metastases. Doctors can use this information to better understand the factors that influence PET scan accuracy and for a more accurate interpretation of PET scan results.

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