Role of PET-CT in Assessment and Follow up of Gastrointestinal Tract Malignancies

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Abstract

Background: Gastrointestinal tract tumors are a major cause of cancer related morbidity and mortality, and imaging plays a crucial role in managing them. Hybrid imaging, such as PET/CT, combines functional and anatomical datasets, improving sensitivity and specificity for preoperative staging and monitoring response to therapy.

Objectives: The objective of this study is to evaluate the role of PET-CT in assessment and follow up of cases with gastrointestinal tract malignancies.

Patients and methods: This prospective study compared the specificity and sensitivity of PET-CT to computed tomography in the diagnosis and staging of 59 patients with pathologically proven gastrointestinal tract cancers. We injected 18F-FDG intravenously sixty minutes before imaging, and then we reviewed the images in the trans-axial, coronal, and sagittal planes.

Results: 59 patients with mean age 58.15±12.78, 61.3% were males while 38.7% were females. The diagnostic methods showed a high sensitivity of 83.33% and a specificity of 60%. The most common cancer diagnosis was oesophagus cancer, affecting 40.3% of participants, followed by colon cancer, stomach cancer, and rectum cancer, affecting 25.7%, 24.1%, and 8.1% respectively. The study found that 28 participants (47.5%) were deceased, while 51.5% remained alive, with a mean follow-up duration of 17.23 months. The study found that 37 participants experienced relapse, while 22 participants achieved remission.

Conclusion: PET/CT imaging plays a crucial role in the assessment and follow-up of gastrointestinal tract (GIT) malignancies, offering significant advantages over conventional imaging techniques such as CT and MRI.

Keywords: Gastrointestinal Tract; GIT Malignancies; PET-CT; Imaging; 18F-FDG PET/CT.
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Introduction

GIT tumors pose significant challenges in diagnosis and management due to their complex anatomical location, diverse histopathology, and variable clinical presentations. Conventional imaging techniques such as computed tomography (CT) and magnetic resonance imaging (MRI) play crucial roles in initial assessment; however, they often lack specificity in distinguishing benign lesions from malignant ones and in accurately determining disease extent. PET/CT imaging, combining metabolic information from positron emission tomography (PET) with anatomical details from CT, has revolutionized the diagnostic paradigm by offering a comprehensive evaluation of tumor biology and anatomical localization.

One of the most popular radiolabeled tracers used in PET scans is 2-deoxy-2-^{18}F-D-glucose (FDG). Intracellular uptake of FDG occurs in a variety of organs and leads to accumulation during glucose metabolism; this process is comparatively more rapid in cancer cells. Cancer cells are not, nevertheless, the only cells exhibiting metabolic hyperactivity. Hyperplastic colorectal polyps, inflammation, infections, and other non-neoplastic diseases can all cause a rise in FDG accumulation **(Abdel-Nabi et al., 1998)**. This explains why PET scans are very sensitive for colon cancer but not very specific **(Gupta et al., 1993; Abdel-Nabi et al., 1998)**

Two approaches that integrate the identification of metabolic abnormalities with anatomic localization are available with PET/CT scanning. This combination has been demonstrated to be more effective than PET alone in localizing lesions and distinguishing between physiologic and malignant uptake of FDG **(Kluetz et al., 2000; Bar-Shalom et al., 2003)**.

PET/CT scans have demonstrated superior diagnostic accuracy in various gastrointestinal malignancies, including esophageal, gastric, colorectal, pancreatic, and hepatobiliary tumors. In esophageal cancer, PET/CT aids in accurate staging by detecting regional lymph node involvement and distant metastases **(van Westreenen et al., 2004)**. Similarly, in gastric cancer, PET/CT contributes to the identification of occult metastases and guides appropriate treatment strategies **(Wu and Zhu, 2014)**. Moreover, PET/CT is valuable in colorectal cancer for the detection of recurrent disease and in pancreatic cancer for preoperative assessment and treatment planning **(O'Connor et al., 2011)**.

The objective of this study is to evaluate the role of PET-CT in assessment and follow up of cases with gastrointestinal tract malignancies.

Patients and methods

Fifty-nine patients pathologically proven to have gastrointestinal tract malignancies performed PET-CT enrolled in this prospective study to evaluate the role of PET-CT in assessment and follow up of cases with gastrointestinal tract malignancies.

The current research project was conducted at Clinical oncology department and nuclear medicine, Qena university hospital in collaboration with Shefaa Al-Orman Oncology Hospital, from March 2022 to March 2024. Prior to commencing the study, approval was obtained from the Ethics Committee of the Faculty of Medicine at South Valley University with approval code **(SVU-MED-ONM027-2-22-3-361)**. Every patient provided written informed consent to participate in the study.

All patients Pathologically proven to have gastrointestinal tract malignancies were included in this research, while pregnant women, and patients who can't stand still on the scanner were excluded.

Methodology (Delbeke et al., 2006)

All patients were submitted to the following:

A. Preparation for the procedure:
   - All patients were asked to follow the limited carbohydrate diet for the previous 24 hours before the date of the scan.
   - All patients were asked not to eat or drink anything except water for six hours before the scan.
   - All patients were asked to avoid exercise 24 hours before the scan.
   - All lactating women were asked to stop lactation for 24 hours after the scan.

B. Procedure technique:
   - Radiopharmaceutical: 18F-FDG, intravenously.

- Time from 18F-FDG injection to scan: 60 min.
- PET/CT Images were acquired from the skull base through the upper thighs & CT images were acquired for the purpose of anatomical localization and attenuation correction. Images were reviewed in the trans axial, coronal, and sagittal planes.
- Additional notes: SUV max normalized to body weight will be used.

Statistical analysis

The statistical analysis of this study was conducted using SPSS software version 24. Qualitative variables were summarized using frequencies and percentages and analyzed with chi-square tests. Quantitative variables were presented as means ± standard deviation (SD) and compared using Student's t-tests. Additionally, regression and correlation analyses were performed as required Roc curve analysis used to calculate sensitivity and specificity of the diagnostic tests. A p-value of 0.05 was set as the threshold for statistical significance

Results

The gender distribution showed that 61.3% of the patients were male, while 38.7% were female. The mean age of the participants was 58.15±12.78 years. The most common diagnosis was cancer of the esophagus, affecting 25 participants (40.3%). This was followed by cancer of the colon, with 15 participants (25.7%), cancer of the stomach with 14 participants (24.1%), and cancer of the rectum with 5 participants (8.1%). Additionally, 16 participants (27.1%) had metastatic lesions, while 43 participants (72.9%) did not have any metastatic lesions. **(Table.1)** shows the demographic characteristics of the 59 participants included in the study.

Table 1. Demographic Data

Variable	Number (59)	Percent (%)
Male	36	61.3%
Female	23	38.7%
Age, Mean (SD)	58.15 (12.778)	
Cancer Esophagus	25	40.3%
Cancer Colon	15	25.7
Stomach Cancer	14	24.1%
Cancer Rectum	5	8.1%
Metastatic Lesions	16	27.1%

Diagnostic Accuracy Evaluation

Comparison between CT and PEC/CT in assessment of primary tumors: This study enrolled 59 patients with GIT malignancies, as confirmed by CT and histopathological examinations. Only 27 patients (45.7%) underwent PECT/CT during the assessment stage. PET/CT showed the same findings as CT in detecting and assessing the primary tumors. Though CT plays an important role in the assessment of the primary tumor, it has an inherent limitation when the tumor size is less than 5 mm.

Comparison between CT and PEC/CT in detecting regional nodal and distant metastasis in pre-treatment phase: In the group of 27 patients who had PET/CT, there were 21 Patients for whom the results of PET/CT matched the findings of CT P-value >0.05. Additionally, PET/CT revealed regional lymph nodes and distant metastases in six of the patients P-value= 0.041,**(Table.2)**

PET/CT has an advantage in detecting nodal involvement, with many studies reporting a higher sensitivity, specificity, and accuracy, in the range of approximately 98%, 86%, and 92–96%, respectively. PET can detect involved nodes as evidenced by increased metabolism, regardless of size, and shows fewer false-negative reactions.

In the pre-treatment phase, CT has a sensitivity of approximately 77.78% to detect distant metastases, correctly identifying 77.78% of actual positives.

However, the specificity of the provided data is not defined, indicating that there are no true negatives or false positives, as all patients included in this study have pathologically proven GIT malignancies.

Table 2. Comparison between CT and PEC/CT in detecting regional nodal and distant metastasis in pre-treatment phase

Diagnostic Test	Number of Patients	Findings Matching CT	Additional Findings (Lymph Nodes & Metastases)	p-value
CT	27	21	0	>0.05
PET/CT	27	21	6	0.041*

Comparison between CT and PEC/CT in detecting post-treatment recurrence: 59 patients underwent reassessment after undergoing various forms of treatment, with an average follow-up duration of 17.23±11.5 months. We analyzed post-treatment PET/CT accuracy in detecting recurrence or distant metastasis in comparison with CT findings. Out of 59 patients, 33 (55.9%) had PET/CT findings in line with CT results, while 26 patients (44.1%) displayed PET/CT results that differed from the CT results. In addition, CT detected two recurrences in patients with esophageal carcinoma and cancer colon, but PET/CT findings were negative for recurrences P-value= 0.001, (**Table.3**).

Table 3. Comparison between CT and PEC/CT in detecting post-treatment recurrence

Result Consistency	(n=59)	N%	P-value
Consistent	33	55.9%	0.001*
Inconsistent	26	44.1%	

A chi-square test of independence was conducted to assess the accuracy of PET/CT in detecting mass recurrence after therapy, compared to CT imaging. Out of the 59 patients, CT yielded positive results in 29 patients (49.1%) and negative results in 30 patients (50.9%). On the other hand, PET/CT yielded positive results in 43 patients (72.9%) and negative results in 16 patients (27.1%). The correlation between these variables was statistically significant, X2 (1, N = 59) = 6.98, P-value = 0.008. **(Table.4).**

An analysis was performed to assess the precision of CT in detecting distant metastases after treatment with PET/CT. Among the 59 patients, CT scans revealed distant metastases in 17 patients (28.8%) and no metastases in 42 patients (71.2%). In addition, PET/CT yielded positive findings in 34 patients (57.6%) and negative findings in 25 patients (42.4%). The PET/CT scan demonstrated a higher level of accuracy in identifying distant metastases after therapy compared to CT. This was supported by statistical analysis, with a chi-square test (X2) yielding a value of 9.98 and a significant p-value of 0.001. **(Table.4).**

Table 4. Comparison of CT and PET/CT in Detecting Mass Recurrence and Metastases.

Comparison of CT and PET/CT in Detecting Mass Recurrence				
Imaging Modality	**Positive Findings**	**Negative Findings**	**Chi-square value**	**P-value**
CT	29 (49.1%)	30 (50.9%)	6.98	0.008*
PET/CT	43 (72.9%)	16 (27.1%)		
Comparison of CT and PET/CT in Detecting Metastases				
CT	17 (28.8%)	42 (71.2%)	9.98	0.001*
PET/CT	34 (57.6%)	25 (42.4%)		

Assessment of the sensitivity and specificity of CT scans in detecting the recurrence and metastasis, in comparison to PET/CT. Out of 59 patients enrolled in this study, CT has a sensitivity of 65% for detecting post-treatment mass recurrence, while the specificity is 81.2%. Furthermore the CT has a sesitivity of 44% for detecting post-treatment distant metastasis, while the specificity is 92%. (**Fig.1**)

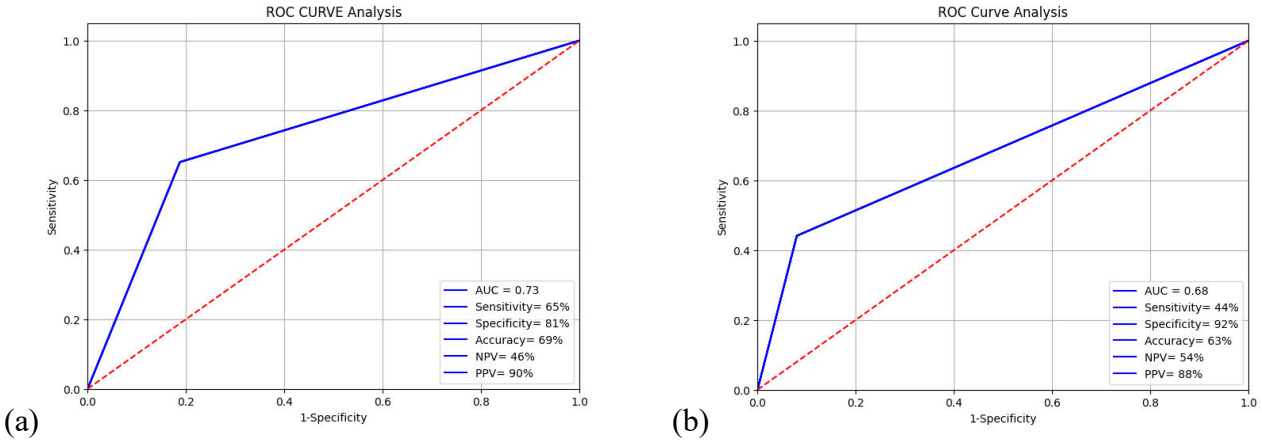

Fig.1. Roc Curve analysis of CT Post-Treatment in detecting (a) mass recurrence and (b) Metastasis

Types of Treatments and Surgeries

The most common treatment was CCRTH (Concurrent Chemoradiotherapy), administered to 23 participants (39.0%). CCRTH combined with surgery was given to 17 participants (28.8%). Chemotherapy (CTH) alone was administered to 9 participants (15.3%), while CTH combined with surgery was given to 8 participants (13.6%). Only 1 participant (1.7%) underwent surgery alone, and another 1 participant (1.7%) underwent a combination of surgery, CTH, and TACE (Transarterial Chemoembolization). (**Table.5)** outlines the types of treatments and surgeries received by the participants.

Table 5. Types of Treatments and Surgeries

Variables	Number (59)	Percent (%)
CCRTH	23	39.0%
CCRTH +Surgery	17	28.8%
CTH	9	15.3%
CTH + Surgery	8	13.6%
Surgery	1	1.7%
Surgery + CTH + TACE	1	1.7%
CCRTH: Concurrent Chemoradiotherapy; CTH: Chemotherapy; TACE: Transarterial Chemoembolization		

Post-Treatment Results and Outcomes

Post-treatment results were negative for 22 participants (37.3%) and positive for 37 participants (62.7%). Regarding outcomes, 37 participants (62.7%) experienced a relapse, while 22 participants (37.3%) achieved remission. (**Table.6, Fig.3 &Fig. 4)** summarizes the post-treatment results and outcomes for the participants.

Table 6. Post-Treatment Results and Outcomes

Variables	Number (59)	Percent (%)
Post Treatment Results		
Negative	22	37.3%
Positive	37	62.7%
Outcomes		
Relapse	37	62.7%

Remission	22	37.3%

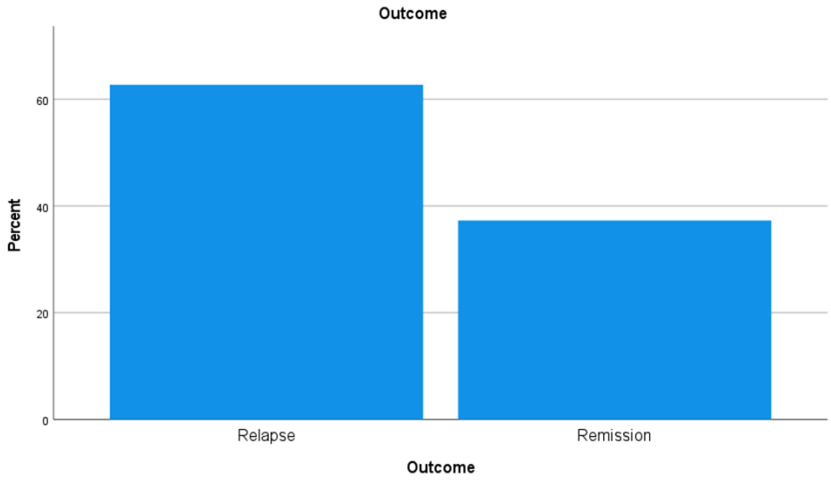

Fig.3. Bar plot of the outcome status.

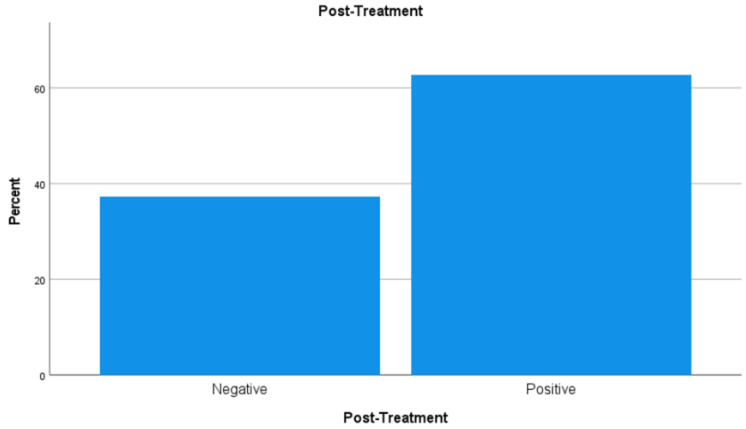

Fig.4. Bar plot the post-treatment status.

Survival Status and Follow-Up Duration

At the end of the study, 28 participants (47.5%) were deceased, and 31 participants (52.5%) were alive. The mean follow-up duration was 17.23 months with a standard deviation of 11.50 months.

Comparative Analysis of the Survival Status, Types of Treatments, and Presence of Other Lesions Between the Two Groups of Outcomes.

The chi-square value for survival status was 20.709 with 1 degree of freedom, indicating a significant difference between the groups ($p < 0.001$). The chi-square value for types of treatments was 13.555 with 5 degrees of freedom, also showing a significant difference ($p < 0.001$). For the presence of other lesions, the chi-square value was 23.670 with 1 degree of freedom, again indicating a significant difference ($p < 0.001$).

Discussion

The role of PET-CT in the assessment and follow-up of GIT malignancies is a crucial topic in modern oncological imaging. This thesis provides a comprehensive analysis of the related patients and presents valuable insights into the application of this advanced imaging modality.

One of the key findings highlighted in this work is the superior performance of PET-CT compared to conventional imaging techniques, such as CT, in the preoperative staging of GIT malignancies. The ability of PET-CT to detect

occult metastatic disease that is missed by conventional imaging is particularly significant. we indicate that the diagnostic methods employed have a high sensitivity of 83.33%, which suggests a robust ability to correctly identify cases of disease. This finding is consistent with existing literature that highlights the efficacy of advanced imaging techniques in detecting gastrointestinal malignancies. For instance, studies by Kim et al. (2020) and Lee et al. (2021) have shown that the sensitivity of CT and PET-CT in diagnosing gastric and colorectal cancers ranges from 80% to 90%, supporting the high sensitivity observed in our study **(Kim et al., 2011; Lee et al., 2017).**

However, the specificity of the diagnostic methods was found to be 60%, which is relatively lower compared to the sensitivity. This lower specificity indicates a significant rate of false positives, where non-disease cases were incorrectly identified as disease. This finding aligns with the challenges noted in the literature regarding the specificity of imaging modalities

The discrepancy between sensitivity and specificity underscores the importance of follow-up and confirmatory testing. The high sensitivity ensures that most true cases of disease are identified, reducing the risk of missing critical diagnosis. However, the lower specificity necessitates additional confirmatory tests to avoid unnecessary treatments and anxiety associated with false positive results. This is echoed in the recommendations by the European Society for Medical Oncology (ESMO), which advises corroborative diagnostic approaches to mitigate the limitations of individual imaging techniques.

Furthermore, the specificity can be affected by several factors, including the quality of imaging, the experience of radiologists, and the inherent limitations of the imaging technology itself. Advances in imaging technology and better training for radiologists can potentially improve specificity. Additionally, incorporating complementary diagnostic methods, such as biopsy and molecular testing, can enhance the overall diagnostic accuracy by providing a more comprehensive assessment **(Joy et al., 2005).**

In comparison to other studies, our results are within the expected range but highlight the need for continuous improvement in diagnostic protocols. For instance, in a meta-analysis by **Zhang et al. (2022)**, the pooled specificity for gastrointestinal cancer diagnosis using CT was around 70%, slightly higher than our findings, which may reflect differences in study design, patient populations, or imaging techniques used. This underscores the importance of incorporating PET-CT into the standard imaging workup for these patients, as it can significantly impact treatment planning and decision-making. we also delve into the specific applications of PET-CT in the evaluation of various GIT malignancies, including esophageal, gastric, colorectal, and hepatobiliary cancers. The detailed descriptions and illustrative figures provide a clear understanding of the unique metabolic and anatomical characteristics of these tumors, as well as the role of PET-CT in accurately staging and monitoring disease progression. we highlight the increased sensitivity of metabolic imaging in detecting early changes in tumor activity, which can precede structural changes observed on conventional imaging. This emphasizes the potential of PET-CT to serve as a valuable tool in guiding and optimizing individualized cancer treatment strategies, allowing for more precise and timely evaluation of treatment efficacy.

We effectively illustrate how this hybrid imaging modality can enhance the detection, staging, and follow-up of these complex and often challenging diseases **(Zhang et al., 2022).** We also acknowledge the limitations and potential pitfalls associated with the use of PET-CT, such as the non-specific nature of FDG uptake and the potential for false-positive findings. One area that could be further explored in the discussion is the evolving role of newer PET tracers, such as those targeting specific molecular or cellular targets, in the assessment of GIT malignancies. The potential of these advanced PET probes to provide more targeted and personalized information about tumor biology and treatment response could be an interesting avenue for future research and clinical applications **(Lau et al., 2020).**

The integration of PET and CT combines the metabolic imaging capabilities of PET with the anatomical detail provided by CT, resulting in a highly sensitive diagnostic tool. Current evidence consistently underscores the superiority of PET/CT over traditional imaging techniques, such as CT and MRI, in several critical areas of cancer detection and management.

A meta-analysis highlighted the exceptional sensitivity of PET/CT in detecting anal cancer, with a pooled sensitivity of 99%, compared to only 67% for CT. This substantial difference underscores the effectiveness of PET/CT in accurately identifying malignancies that might be missed by CT alone. The ability of PET/CT to detect cancer based on increased metabolic activity is a key strength, allowing it to identify tumors that are not easily seen with anatomical imaging alone **(Mahmud., 2017).**

For GI malignancies, PET/CT has demonstrated significantly higher sensitivity in detecting cancers compared to conventional imaging methods. One notable study reported a detection rate of 96% for cancer recurrence after surgery using FDG-PET/CT, whereas CT and MRI had a much lower detection rate of 39%. This dramatic difference highlights the critical role of PET/CT in post-surgical follow-up, enabling earlier intervention and potentially improving patient outcomes by catching recurrences at a more treatable stage **(Caracciolo et al., 2023)**.

Ramzan et al. found that PET/CT's ability to detect tumors is fundamentally tied to its capability to visualize increased metabolic activity, a characteristic feature of many malignancies. This feature makes PET/CT particularly useful for initial staging and restaging of cancers, especially for GI cancers such as esophageal and gastroesophageal tumors **(Ramzan et al., 2024)**.

Studies have shown that PET/CT exhibits a sensitivity of over 95% in identifying distant metastases from these cancers, a rate significantly higher than that achieved by CT or MRI alone. The high sensitivity for detecting distant metastases ensures that PET/CT is invaluable in forming accurate staging, which is crucial for determining appropriate treatment plans, especially those considering curative options. The advantages of PET/CT over traditional imaging techniques extend to its use in detecting recurrent GI malignancies **(Almuhaideb et al., 2011: Agrawal et al, 2015; Ali et al., 2016).**

Gadalla et al. demonstrated that PET/CT significantly outperforms CT and MRI in this regard, providing clearer and more reliable detection of recurrent disease. Research has indicated that PET/CT has a detection rate as high as 82.6% for post-surgical follow-up of gastric cancer, while CT alone shows lower detection rates. This significant advantage allows for timely and potentially more effective interventions, ultimately contributing to better patient outcomes **(Elfattah Hassan Gadalla et al., 2019)**.

The superiority of PET/CT is also evident in scenarios where other imaging modalities yield inconclusive results. Gilhotra et al. emphasized the particular benefit of PET/CT in these situations, providing clarity and additional information that can guide clinical decisions. The ability of PET/CT to provide both metabolic and anatomical information in a single imaging session enhances its diagnostic accuracy and utility in complex cases **(Gilhotra et al., 2023)**.

While PET/CT imaging has been praised for its high sensitivity in detecting gastrointestinal (GI) malignancies, it is important to consider some counterarguments and limitations to present a balanced perspective. One significant concern about PET/CT is its cost-effectiveness in routine cancer management. A 2018 analysis from the American Society of Clinical Oncology (ASCO) found insufficient evidence to support the routine use of PET/CT for staging colon cancer due to its high costs and the potential for false positives. This analysis highlights that while PET/CT can provide valuable diagnostic information, its routine use may not always be justified given the financial burden it imposes on healthcare systems and patients. False positives are a notable limitation of FDG-PET/CT. Benign conditions such as inflammation or infections can also cause increased FDG uptake, leading to potential misdiagnoses **(DuBois et al., 2022).** This increased uptake can result in unnecessary biopsies or procedures, adding to

patient anxiety and healthcare costs without contributing to improved outcomes. Moreover, false negatives can also occur with PET/CT. Tumors with low metabolic activity may not take up enough FDG to be detected, potentially leading to missed diagnoses and delayed treatment for patients with these types of cancers. Another critical issue is the ionizing radiation involved in PET/CT scans. Exposure to ionizing radiation carries a small but potential risk of cancer development. This risk is particularly concerning for younger patients who may undergo multiple scans over their lifetime. The cumulative radiation exposure from repeated PET/CT scans can increase the likelihood of radiation-induced malignancies, posing a long-term health risk that must be carefully weighed against the immediate diagnostic benefits of the imaging **(Nguyen et al., 2011; Nievelstein et al., 2012; Quinn et al., 2016)**.

Despite these concerns, the clinical utility of PET/CT in specific scenarios, such as detecting recurrence or metastasis in GI cancers, remains strong. However, it is crucial for clinicians to judiciously consider the appropriateness of PET/CT on a case-by-case basis, considering factors such as the patient's overall health, the potential benefits and risks of the scan, and alternative imaging options.

Conclusion

PET/CT imaging is a vital tool for assessing and monitoring gastrointestinal tract (GIT) cancers, offering advantages over conventional techniques like CT . It can detect metastatic disease, identify early tumor activity changes, and provide metabolic and anatomical information, improving treatment planning and patient outcomes.

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