BMC Cancer

RESEARCH Open Access

Dual-Time-Point ^{18}F-FDG PET/CT imaging in the diagnosis of colorectal carcinoma or advanced adenoma in patients with fixed focal colorectal ^{18}F-FDG uptake

Baosheng Meng[1,2], Yuanyuan Ma[1,2], Yuetao Wang[1,2], Mingge Zhou[1,2*] and Chen He[1,2*]

Abstract

Background Fixed focal fluorine 18 fluorodeoxyglucose (^{18}F-FDG) uptake in colorectal areas is commonly seen in PET/CT scan and may indicates malignant tumor. This study aims to investigate the diagnostic efficacy of dual-time-point ^{18}F-FDG PET/CT in detecting colorectal carcinoma or advanced adenoma in patients with fixed focal colorectal ^{18}F-FDG uptake.

Methods A retrospective analysis was conducted on patients who underwent dual-time-point ^{18}F-FDG PET/CT scans between January 2019 and December 2023. Patients showing fixed focal colorectal ^{18}F-FDG uptake in both early and delayed scans, and subsequently undergoing colonoscopy within one month, were included in the study. Advanced adenoma was defined as an adenoma larger than 10 mm in diameter and/or with villous histology and/or presenting with high-grade dysplasia. The maximum standardized uptake value (SUV) in the early and delayed scans, as well as the retention index (RI), were compared between colorectal carcinoma/advanced adenomas and non-advanced lesions. Predictive factors for colorectal carcinoma/advanced adenoma were identified by uni- and multivariable analysis.

Results A total of 122 patients were enrolled in this study. A total of 141 lesions was studied, 80 (56.7%) of which were diagnosed as colorectal carcinoma or advanced adenoma. When compared with non-advanced lesions, colorectal carcinoma/advanced adenoma had higher SUVmax in delayed scan (25.1 ± 14.2 vs. 14.5 ± 7.5, P<0.001), and higher RI (32.9%±25.4% vs. 7.8%±28.4%, P<0.001) in dual-time-point PET/CT. SUVmax in delayed scan (odds ratio [OR],1.084; 95% confidence interval [CI]: 1.037, 1.134; P<0.001) and RI (OR, 20.120; 95% CI: 4.068, 99.516; P<0.001) were identified as independent predictors for colorectal carcinoma/advanced adenoma by multivariable logistic regression analysis. When combining the SUVmax in the delayed scan with the retention index, the area under the receiver operating characteristic (ROC) curve achieved 0.801, and the sensitivity and specificity for predicting colorectal carcinoma/advanced adenoma were found to be 65.0% and 80.3%, respectively. Based on the threshold values of

*Correspondence:
Mingge Zhou
zhoumingge0417@suda.edu.cn
Chen He
13082510827@163.com

Full list of author information is available at the end of the article

SUVmax in the delayed scan and RI, we observed prediction rates of 13.9% (5 out of 36), 58.6% (34 out of 58), and 87.2% (41 out of 47) for colorectal carcinoma/advanced adenoma in the low-, moderate-, and high-risk subgroups, respectively.

Conclusions Dual-time-point PET/CT aids in distinguishing between colorectal cancer/advanced adenoma and non-advanced lesions in fixed focal FDG uptake. Higher SUVmax in delayed scan and higher RI are predictive factors for colorectal carcinoma/advanced adenoma.

Keywords ^{18}F-FDG PET/CT, SUVmax, Retention index, Colorectal carcinoma, Advanced adenoma

Background

Colorectal cancer, a malignant tumor ranking third in incidence and second in mortality globally, poses a significant public health burden with rising rates. Modern medicine prioritizes not only early diagnosis and treatment but also prevention of cancer. It is well known that colorectal adenomas are precancerous lesions. Notably, advanced colorectal adenoma, which is defined as an adenoma larger than 10 mm in diameter and/or with villous histology and/or presenting with high-grade dysplasia, carries a high risk of developing into cancer [1, 2]. Therefore, accurate identification of colorectal cancer as well as advanced adenoma is crucial to reducing the incidence and mortality of colorectal cancer.

Fluorine 18 fluorodeoxyglucose (^{18}F-FDG) PET/CT, integrating anatomical and glucose metabolism information, is a widely used imaging tool in the management of malignant tumors. Incidental findings of focal FDG uptakes in colorectal areas are common in PET/CT scans [3]. Dual-time-point PET/CT, a method employing delayed scans of suspicious lesions identified in early scans, is usually used to observe changes in focal FDG uptakes' shapes, positions, and standardized uptake values (SUV). ^{18}F-FDG PET demonstrates glucose metabolic activity in both physiological tissues and pathological lesions, lacking intrinsic specificity for malignant tumors. So fixed focal FDG uptakes in dual-time-point PET/CT may be caused by malignant lesions as well as benign lesions (including physiological uptakes), such as muscular peristalsis, inflammation, and non-advanced adenomas. While accurate identification of colorectal cancer/advanced adenoma is essential for treatment decisions, unnecessary investigations of potentially benign or physiological FDG uptake can delay diagnoses and treatment of other underlying conditions. However, distinguishing between benign and malignant lesions in fixed focal FDG uptake remains challenging. The retention index (RI), measuring relative changes in lesion's SUV between early and delayed scans, is potential in the differentiation of various kinds of tumors [4, 5, 6, 7, 8]. This study aims to investigate whether SUV and RI differ between colorectal cancer/advanced adenoma and non-advanced lesions, and whether SUV combined with RI helps identify colorectal carcinoma/advanced adenoma in patients with fixedfocal FDG uptake in colorectal areas.

Methods

Patients

This retrospective study was approved by the Institutional Review Board of the Third Affiliated Hospital of Soochow University. The requirement to obtain informed consent was waived due to the retrospective nature of the study. The patients who underwent dual-time-point ^{18}F-FDG PET/CT scans between January 2019 and December 2023 in the Department of Nuclear Medicine in the Third Affiliated Hospital of Soochow University were involved in the present study. Inclusion criteria: (1) Focal FDG uptake within the colonic wall identified in both early (1 h post-injection) and delayed (2 h post-injection) PET/CT scans, and no obvious movement or shape change observed in the delayed scan compared with the early scan; (2) colonoscopy performed within one month of the PET/CT scan; (3) detailed colonoscopy reports and pathological findings were available. Exclusion criteria: (1) Known history of intestinal malignant tumor before the PET/CT scan; (2) history of taking metformin within 48 h before the PET/CT scan; and (3) early and delayed scans were not performed at the scheduled time points (Fig. 1).

Dual-time-point PET/CT imaging

The PET/CT scan was performed using Siemens Biograph mCT (64) system, and the radiotracer was ^{18}F-FDG (produced by Jiangsu Huayi Technology Co., Ltd.), with a radiochemical purity over than 95%. All patients were required to fast for at least 6 h, and the blood glucose level and body weight was measured. Then the intravenous injection of ^{18}F-FDG (3.70–5.55 MBq per kilogram of body weight) was done. Early PET/CT scan from the skull base to proximal femur was performed 1 h after injection. For the first step, the four-dimensional technology, CareDose, was used for the CT scan. Tube current was adapted automatically to varying shapes, anatomical structures, and tissue density of human bodies, with reference to 60 ~ 180 mAs, 100 kV of tube voltage, pitch of 0.8, 0.5 s of single-layer rotation time for ball tube and 5 mm of layer thickness. PET scan was conducted after

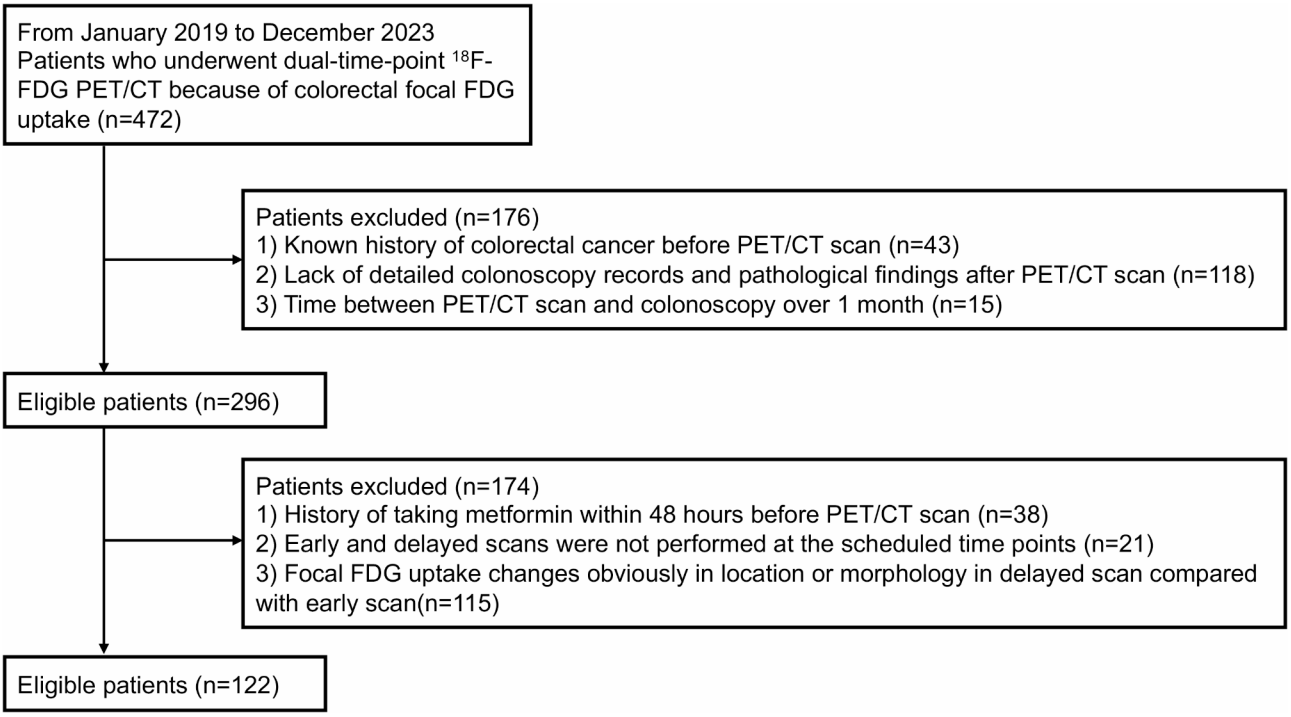

Fig. 1 Study flowchart shows inclusion and exclusion criteria. A total of 122 patients between January 2019 and December 2023 were included in the present study

the CT scan. A three-dimensional model was used for image acquisition, with 5 ~ 7 bed scans conducted based on patient height. The time spent on image acquisition was 2 min per bed. Syngo TureD software was adopted for image reconstruction to generate cross-sections, coronal planes, sagittal tomographs, and 3D projection images. Delayed PET/CT scan was conducted 2 h after injection, focusing on the abdominal region containing the focal FDG uptake identified in early scan. All other scan parameters remained the same. Patients were instructed to drink at least 500mL of water between the two time points.

PET/CT image analysis

PET/CT images were evaluated by two experienced nuclear medicine physicians (Zhou M and He C). Firstly, all patients' PET/CT images were evaluated for the presence of fixed focal FDG uptake. Focal FDG uptake refers to PET lesions identified through multiplanar evaluation (axial, coronal, and sagittal planes) demonstrating localized metabolic activity, distinct from linear or diffuse uptake patterns. Fixed FDG uptake indicates lesions maintaining consistent morphology (e.g., no transition from nodular to linear configuration) and positional stability between early scan and delayed scan. Accounting for intestinal peristalsis, positional shifts were assessed with lenient criteria. It is particularly noteworthy that, metabolically active lesions demonstrating FDG uptake exclusively in either the early scan or delayed scan were excluded from the fixed focal uptake classification. Secondly, volume of interest (VOI) was drawn by using Syngo TureD software, and parameters on both early and delayed scans were measured. Physiological uptake areas were carefully excluded when drawing VOI. Syngo TureD automatically calculated the maximum standardized uptake value (SUVmax) for both early ($SUVmax_1$) and delayed ($SUVmax_2$) scans. RI was calculated using the following formula: $RI = (SUVmax_2 - SUVmax_1) / SUVmax_1 \times 100\%$.

Statistical analysis

Data analysis was performed using IBM SPSS 29.0 software. The Kolmogorov-Smirnov test assessed the normality of continuous variables. Normally distributed data are presented as mean ± standard deviation. Independent sample t test was used to compare group differences for normally distributed data. Categorical data are presented as frequencies and percentages, and group comparisons were performed using the chi-square test. Logistic regression analysis was conducted to identify independent predictors. The receiver operating characteristic (ROC) curve was utilized to evaluate the diagnostic value of the model, determine the optimal cutoff value, and calculate sensitivity and specificity. All statistical tests were two-sided, and $P < 0.05$ indicated a significant difference.

Table 1 Patient demographics based on colonoscopy results

Colonoscopy Results	No. of Lesions	No. of Patients	Age (y)	Sex (M/F)	Location of Lesions	Intentions of PET/CT scan
Non-advanced Lesions	61	57	66.2 ± 10.8	35/22	Ascending colon: 28(45.9%) Transverse colon: 6(9.8%) Descending colon: 7(11.4%) Sigmoid colon: 13(21.3%) Rectum:7(11.4%)	Diagnosis of other primary carcinomas: 18(31.6%) Staging and restaging of other primary carcinomas:21(36.8%) Evaluating therapeutic effects of other primary carcinomas: 12(19.7%) Elevated tumor markers: 3(4.9%) Fever of known origin: 2(3.5%) Abdominal pain of unknown origin: 1(1.8%)
Non-advanced adenoma	12	9	63.6 ± 12.9	7/2		
Hyperplastic polyp	23	22	67.4 ± 9.7	11/11		
Colitis	5	5	58.2 ± 13.0	4/1		
Normal colon	21	21	61.8 ± 17.5	13/8		
Advanced Lesions	80	73	68.9 ± 9.6	49/24	Ascending colon: 23(28.8%) Transverse colon: 8(10.0%) Descending colon: 10(12.5%) Sigmoid colon: 26 (32.5%) Rectum:13(16.3%)	Diagnosis of other primary carcinomas: 31(42.5%) Staging and restaging of other primary carcinomas: 22(30.1%) Evaluating therapeutic effects of other primary carcinomas: 7(9.6%) Elevated tumor markers: 8(11.0%) Fever of known origin: 3(4.1%) Autoimmune disease: 2(2.7%)
Advanced Adenoma	38	32	65.6 ± 11.4	26/6		
Carcinoma	42	41	70.8 ± 4.8	23/18		

Table 2 Comparison of ^{18}F-FDG uptake and retention between groups

Colonoscopy Results	Carcinoma/ Advanced Adenoma	Non-advanced Lesions	t	*P* Value
No. of Lesions	80	61		
$SUVmax_1$	19.6 ± 11.6	13.5 ± 6.1	3.565	0.002
$SUVmax_2$	25.1 ± 14.2	14.5 ± 7.5	5.735	<0.001
RI	32.9%±25.4%	7.8%±28.4%	5.438	<0.001

Results

Study population and colonoscopy confirmation of fixedfocal FDG uptake

This study enrolled a total of 122 patients with 141 fixed focal FDG uptakes in colorectal areas. Among these foci, 80 (56.7%) were classified as colorectal carcinoma or advanced colorectal adenoma, whereas the remaining 61 (43.3%) were non-advanced lesions. Among the 80 lesions of colorectal carcinoma/advanced colorectal adenoma, 42 were adenocarcinomas, including 4 cases of mucinous adenocarcinoma; lesions of advanced colorectal adenoma comprised 38 cases, all of which were larger than 10 mm in diameter, 20 cases of which with their villous histology > 25% and 17 of which with high-grade dysplasia. Among the 61 non-advanced lesions, 23 cases were hyperplastic polyps, 12 were non-advanced colorectal adenomas, 5 were colitis and 21 had negative findings in colonoscopy (Table 1).

Higher SUVmax and RI were associated with colorectal carcinoma /Advanced adenoma

Table 2 summarizes PET/CT parameters for both groups (colorectal carcinoma/advanced adenoma vs. non-advanced lesions). The group of colorectal carcinoma/advanced adenoma displayed significantly higher $SUVmax_1$, $SUVmax_2$, and RI than the group of non-advanced lesions (t = 3.565, $P = 0.002$; t = 5.735, $P < 0.001$; t = 5.438, $P < 0.001$, respectively). There were no significant differences between the groups in terms of age and sex ($P > 0.05$).

$SUVmax_2$ and RI as independent predictors for colorectal carcinoma/advanced adenoma

Logistic regression was used to identify independent predictors for colorectal carcinoma/advanced adenoma. Univariate analysis revealed significant correlations between parameters ($SUVmax_1$, $SUVmax_2$, and RI) and the presence of colorectal carcinoma/advanced adenoma ($P = 0.002$, $P < 0.001$, and $P < 0.001$, respectively). As $SUVmax_1$ and $SUVmax_2$ were highly correlated [Pearson Correlation Coefficient (r) = 0.925, $P<0.001$], they were separately included in multivariate analysis, which identified $SUVmax_2$ and RI as the independent predictors. Higher $SUVmax_2$ (OR: 1.084; 95% CI: 1.037 ~ 1.134; $P < 0.001$) and higher RI (OR: 20.120; 95% CI: 4.068 ~ 99.516; $P < 0.001$) were both associated with an increased risk of the lesion being colorectal carcinoma/advanced adenoma (Table 3). The representative cases presented in Fig. 2 demonstrate that higher $SUVmax_2$ and RI exhibit a significant association with colorectal carcinoma/advanced adenoma.

Development of a prediction model combining $SUVmax_2$ and RI

The diagnostic value of $SUVmax_1$, $SUVmax_2$, RI, and $SUVmax_2$ combined with RI for detecting colorectal carcinoma/advanced adenoma was evaluated using ROC curves. The area under the curve (AUC) for $SUVmax_1$, $SUVmax_2$ and RI were 0.645 (95% CI: 0557 ~ 0.736), 0.741 (95% CI: 0.661 ~ 0.821), and 0.756 (95% CI: 0.674 ~ 0.838), respectively. The combined model incorporating both $SUVmax_2$ and RI achieved a higher AUC

Table 3 Uni- and multivariable logistic regression analysis of predictive factors for colorectal carcinoma/advanced adenoma

Variable	Univariable Analysis			Multivariable Analysis					
				Model 1			Model 2		
	OR	95%CI	*P* Value	OR	95%CI	*P* Value	OR	95%CI	*P* Value
$SUVmax_1$	1.087	1.037 ~ 1.140	0.006	…	…	…	1.012	0.986 ~ 1.039	0.371
$SUVmax_2$	1.103	1.054 ~ 1.154	<0.001	1.084	1.037 ~ 1.134	<0.001	…	…	…
RI	37.167	7.948 ~ 173.792	<0.001	20.120	4.068 ~ 99.516	<0.001	65.869	12.091 ~ 358.844	<0.001

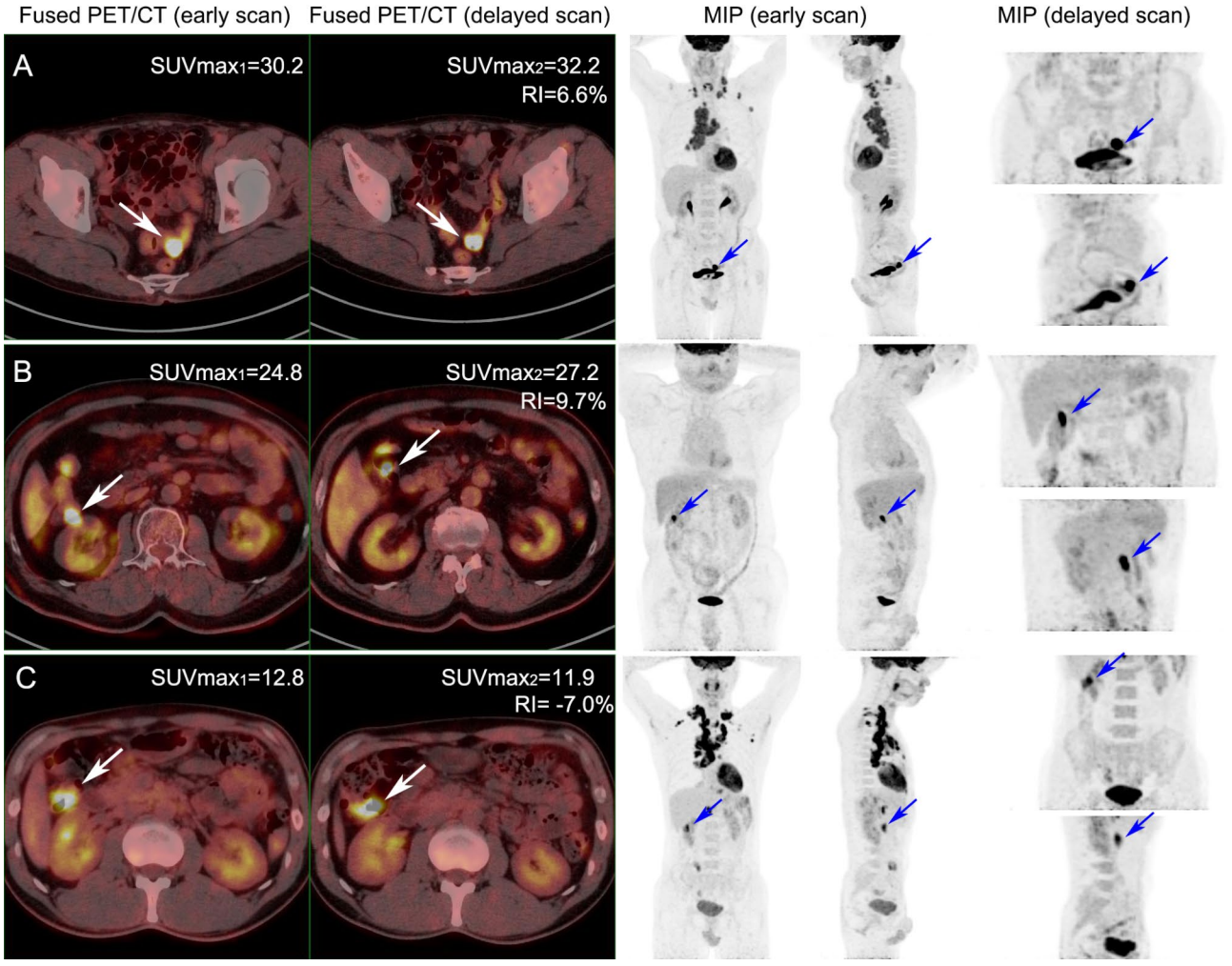

Fig. 2 Dual-time-point fluorine 18 (^{18}F) fluorodeoxyglucose (FDG) PET/CT images show colorectal carcinoma, advanced adenoma and physiological uptake. (**A**) PET/CT images in a 66-year-old man diagnosed as small cell lung cancer, with a lesion with ^{18}F-FDG uptake located in the sigmoid colon (max standardized uptake value in early scan ($SUVmax_1$) = 30.2, maximum standardized uptake value in delayed scan ($SUVmax_2$) = 32.2, RI = 6.6%). Colonoscopy was performed and pathologic analysis revealed adenocarcinoma. (**B**) PET/CT images in a 67-year-old man with elevated level of carbohydrate antigen 72 – 4, with a lesion with ^{18}F-FDG uptake located in the ascending colon ($SUVmax_1$ = 24.8, $SUVmax_2$ = 27.2, RI = 9.7%). Colonoscopy was performed and pathologic analysis revealed villous tubular adenoma. (**C**) PET/CT images in a 33-year-old man diagnosed as Hodgkin lymphoma, with a lesion with ^{18}F-FDG uptake located in the ascending colon ($SUVmax_1$ = 12.8, $SUVmax_2$ = 11.9, RI = -7.0%). The subsequent colonoscopy examination showed negative results. MIP: maximal intensity projection

of 0.801 (95% CI: 0.729 ~ 0.873), as is shown in Fig. 3. Based on the ROC curve analysis, the optimal cutoff value for $SUVmax_2$ was 21.1 (sensitivity: 53.8%, specificity: 88.5%), and that for RI was 5.9% (sensitivity: 91.3%, specificity: 52.5%).Using these cutoff values, the 141 lesions were categorized into three risk groups: low-risk ($SUVmax_2 \leq 21.1$ and RI ≤ 5.9%), medium-risk ($SUVmax_2 > 21.1$ and RI ≤ 5.9%, or $SUVmax_2 \leq 21.1$ and RI > 5.9%), and high-risk ($SUVmax_2 > 21.1$ and RI > 5.9%) groups. The proportions of colorectal carcinoma/advanced adenoma in the three groups were 13.9% (5/36), 58.6% (34/58), and 87.2% (41/47), respectively, with a significant statistical

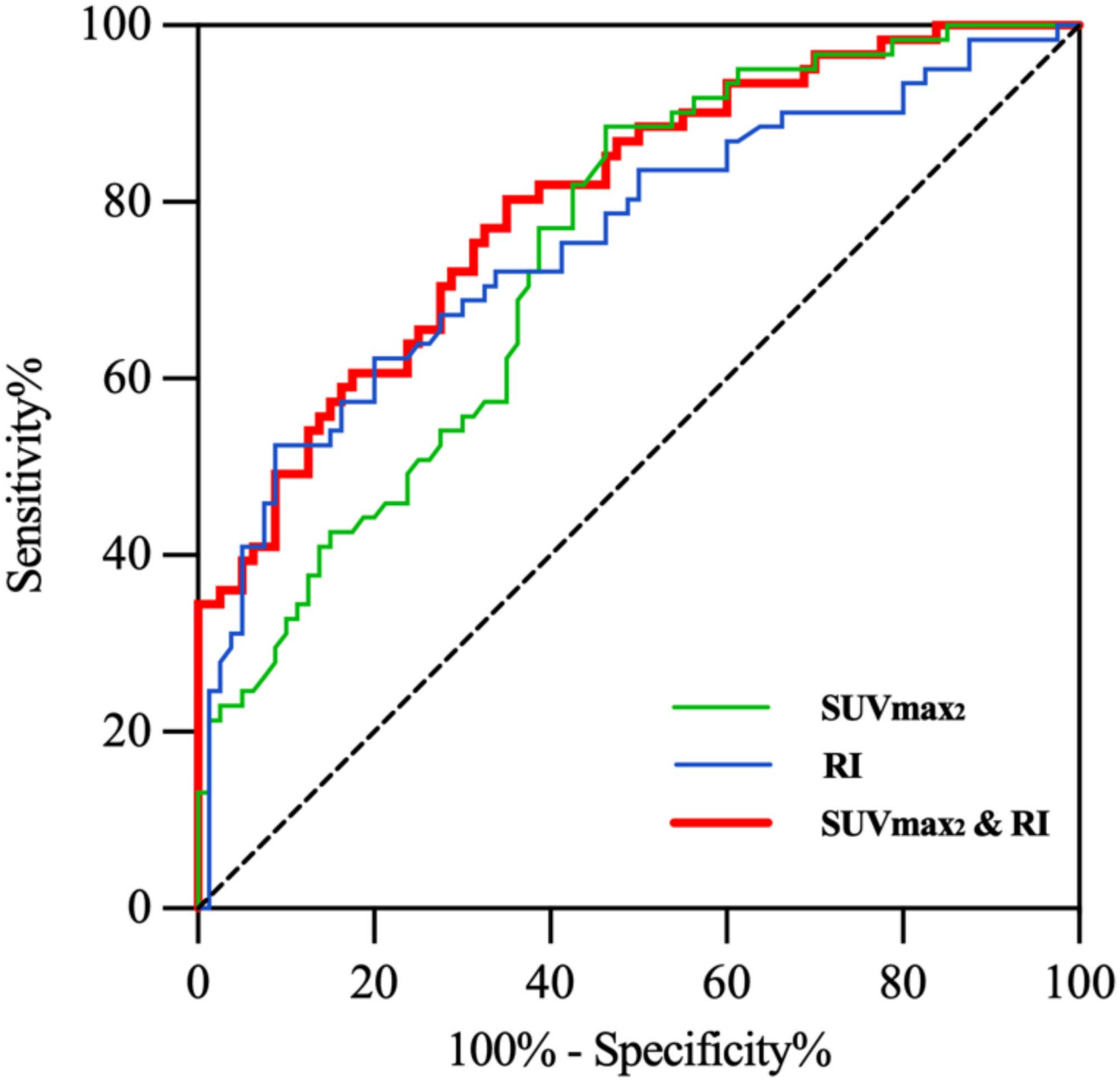

Fig. 3 Area under the receiver operating characteristic curve (AUC) for detecting colorectal carcinoma/advanced adenoma using dual-time-point fluorine 18 (^{18}F) fluorodeoxyglucose (FDG) PET/CT. The AUCs of $SUVmax_2$ and RI were 0.741 (95% confidence interval [CI]: 0.661, 0.821) and 0.756 (95% CI: 0.674, 0.838), respectively. The combined AUC for $SUVmax_2$ and RI was 0.801 (95% CI: 0.729, 0.873)

difference ($\chi^2 = 44.819$, $P < 0.001$) being identified between groups (Table 4).

Discussion

False-positive lesions identified by ^{18}F-FDG PET/CT are commonly seen in the intestines, with some appearing as fixed focal FDG uptakes on dual-time-point imaging, complicating the differentiation between colorectal carcinoma/advanced adenoma and benign lesions. SUV is a widely used parameter that is easy to measure and has good repeatability. RI, calculated from the SUV, has similar advantages. We hypothesized that lesions of different natures would vary in the uptake and retention of FDG, and investigated whether SUV and RI could help distinguish colorectal carcinoma/advanced adenoma from non-advanced lesions. Our study found that $SUVmax_1$, $SUVmax_2$, and RI were significantly higher in the carcinoma/advanced adenoma group compared with the non-advanced group. Moreover, $SUVmax_2$ and RI emerged as independent predictors for carcinoma/advanced adenoma. ROC curve analysis identified $SUVmax_2 > 21.1$ and RI > 5.9% as optimal cutoff values for

Table 4 Prediction rate of colorectal carcinoma/advanced adenoma in Low-, Moderate-, and High-Risk groups

Group	No. of Lesions	No. of Colorectal Carcinoma /Advanced Adenoma	No. of Non-advanced Lesions	*P* Value
Low Risk	36	5	31	<0.001
Moderate Risk	58	34	24	<0.001
High Risk	47	41	6	<0.001
Total	141	80	61	…

Note. According to the thresholds of $SUVmax_2$ and RI, patients were divided into three groups: a low-risk group ($SUVmax_2 \leq 21.1$ and RI ≤ 5.9%), a moderate-risk group ($SUVmax_2 \leq 21.1$ and RI>5.9%, or $SUVmax_2 > 21.1$ and RI ≤ 5.9%), and a high-risk group ($SUVmax_2 > 21.1$ and RI>5.9%)

differentiating between carcinoma/advanced adenoma and non-advanced lesions. Patients were categorized into low-, moderate-, and high-risk subgroups based on $SUVmax_2$ and RI, with a higher incidence of carcinoma/advanced adenoma observed in the high- and moderate-risk groups than in low-risk group. This study revealed the differences in FDG uptake and retention between carcinoma/advanced adenoma and non-advanced lesions.

The wide application of ^{18}F-FDG PET/CT imaging is based on Warburg effect, which leads to a phenomenon that malignant tumors have a relatively high demand for glucose [9]. However, Warburg effect is not exclusive to malignant tumors, as increased glucose uptake can also occur in benign tumors and inflammatory lesions. In our study, both $SUVmax_1$ and $SUVmax_2$ of carcinoma/advanced adenoma were higher than those of non-advanced lesions, indicating a higher glucose demand in malignant lesions than in benign lesions. Additionally, the partial volume effect of PET might lead to an underestimation of SUV in small lesions [10]. Since non-advanced colorectal adenomas are typically smaller, they tend to show lower SUV values than advanced lesions. High specificity and low sensitivity were seen with an $SUVmax_2$ cutoff value of 21.1, indicating that non-advanced lesions are unlikely to retain FDG at a high level in delayed scans. Interestingly, we found no differences in SUVmax between carcinoma and advanced adenoma, and tubular adenomas with villous histology even exhibited higher SUVmax than adenocarcinomas, as is shown in Supplementary Table 1. So SUVmax may not be valuable in differentiating adenocarcinoma from advanced adenomas.

RI reflects relative changes in SUV between early and delayed scans. The SUV-Time curve is associated with the processes of FDG's in and out of cells. FDG enters cells via glucose transporters (GLUT), gets phosphorylated by hexokinase (HK), and remains in the cells, while non-phosphorylated FDG can be washed out. This process is modeled by a three-compartment pharmacokinetic system, with k1 representing FDG transport into cells, k2 indicating washout velocity, and k3 denoting phosphorylation velocity [11]. Previous studies suggest that RI correlates with higher levels of GLUT and HK expression (k1 and k3 parameters). Tsuchida et al. analyzed RI and kinetic parameters of lung squamous cell carcinoma and adenocarcinoma and found that RI, k1, and k3 present a similar or parallel tendency between groups (lung squamous cell carcinoma > moderately and poorly differentiated adenocarcinoma > well differentiated adenocarcinoma), which prompts that RI is correlated with k1 and k3 [12]. Lee et al. found that RI in colorectal cancer correlates closely with GLUT1 expression [13], while Higashi et al. observed a positive correlation between RI and HK2 levels in pancreatic cancer [14]. Our study found high sensitivity but low specificity of RI when using a cutoff value of 5.9%. It indicates that lower RI is unlikely seen in advanced lesions, maybe due to high levels of expression of GLUT and HK in advanced lesions. It is a pity that neither immunohistochemical analyses nor dynamic PET images were conducted due to the restriction of the study design, so we were unable to analyze the relationship between RI, kinetic parameters and the expression of GLUT and HK in the present study. Among 39 lesions with RI < 5.9%, only two were carcinomas, both mucinous adenocarcinomas, possibly due to their mucin content resulting in low level of FDG accumulation.

Kashiwagi et al. found that although the SUVs of advanced lesions in both early and delayed scans were significantly higher than those of non-advanced lesions, there was no significant difference in RI values [15]. Their study included only 33 patients undergoing delayed imaging, which is far fewer than the number of patients in our study. Additionally, the study did not account for metformin use, which could increase intestinal FDG uptake [16, 17]. These factors may explain the discrepancies between our findings and their results. Peng et al. found that the false-positive FDG uptake is more commonly observed in the right colon [18]. Kashiwagi et al. indicated 8 out of 10 with PET/CT positive normal colons according to colonoscopy were located in the right colon [15]. Our study had similar findings that nearly half of the non-advanced lesions (28/61, 45.9%) were in the ascending colon. This phenomenon is thought to be related to the high concentration of glucose-metabolizing lymphatic cells in this area [19].

Although combining SUV with RI improves the ability of identifying colorectal carcinoma/advanced adenoma, it doesn't mean PET/CT should be suggested as a screening tool, because our study did not evaluate the potential for missed diagnoses of carcinoma/advanced adenoma using PET/CT. Our findings apply only to the discrimination of incidental and fixed colorectal focal FDG uptake in dual-time-point PET/CT.

This study has some limitations. Firstly, it is a retrospective and single-center study. Secondly, the exclusion of patients who lack colonoscopy examinations could introduce bias. Finally, lesion size, a crucial differentiating factor, was not included due to challenges in the measurement on CT images without bowel preparation. We plan to utilize metabolic tumor volume to assess its diagnostic value in future studies.

Conclusions

In conclusion, our study demonstrates the value of dual-time-point PET/CT for discrimination of fixedfocal FDG uptakes in colorectal areas. SUVmax in delayed scan and RI are independent predictive factors for colorectal carcinoma/advanced adenoma. The combined use of these two indexes improves the accuracy of identifying colorectal carcinoma/advanced adenoma. In the future, multicenter studies with larger sample sizes are needed to help validate our findings and to provide valuable information for disease management.

Abbreviations

^{18}F-FDG	Fluorine 18 (^{18}F) Fluorodeoxyglucose
PET/CT	Positron Emission Tomography/Computed Tomography
SUV	Standardized Uptake Value
RI	Retention Index
OR	Odds Ratio
CI	Confidence Interval
ROC Curve	Receiver Operating Characteristic Curve
VOI	Volume of Interest
GLUT	Glucose Transporter
HK	Hexokinase
MIP	Maximal Intensity Projection

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12885-025-14129-5.

Supplementary Material 1

Acknowledgements

Not applicable.

Author contributions

M.Z. and C.H. conceived and designed the analysis, collected the data, performed data analysis, wrote and reviewed the paper. B.M. and Y.M. collected the data, performed data analysis, wrote the paper. Y.W. reviewed the paper. All authors read and approved the final manuscript.

Funding

This work was supported by National Natural Science Foundation of China (82001858); "333 Project" of Jiangsu Province; Changzhou Clinical Medical Center (Nuclear Medicine, CZZX202204); Changzhou Sci & Tech Program (Grant No. CJ20235086); Changzhou Talent Program (Grant No. CQ20230115).

Data availability

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

This study was conducted in accordance with the ethical principles of the Declaration of Helsinki (https://www.wma.net/policies-post/wma-declaration-of-helsinki/) and was approved by the Institutional Review Board of the Third Affiliated Hospital of Soochow University approved the study. The requirement to obtain informed consent was waived due to the retrospective nature of the study.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

Note

According to the thresholds of $SUVmax_2$ and RI, patients were divided into three groups: a low-risk group ($SUVmax_2 \leq 21.1$ and $RI \leq 5.9\%$), a moderate-risk group ($SUVmax_2 \leq 21.1$ and $RI > 5.9\%$, or $SUVmax_2 > 21.1$ and $RI \leq 5.9\%$), and a high-risk group ($SUVmax_2 > 21.1$ and $RI > 5.9\%$).

Author details

[1]Department of Nuclear Medicine, The Third Affiliated Hospital of Soochow University, Changzhou 213003, Jiangsu, China
[2]Changzhou Key Laboratory of Molecular Imaging, Changzhou 213003, Jiangsu, China

Received: 5 August 2024 / Accepted: 9 April 2025
Published online: 22 April 2025

References

1. Gupta S, Lieberman D, Anderson JC, Burke CA, Dominitz JA, Kaltenbach T, et al. Recommendations for Follow-Up after colonoscopy and polypectomy: A consensus update by the US Multi-Society task force on colorectal cancer. Am J Gastroenterol. 2020;115:415–34.
2. Nguyen LH, Goel A, Chung DC. Pathways of colorectal carcinogenesis. Gastroenterology. 2020;158:291–302.
3. Rainis T, Kaidar-Person O, Keren D, Lavy A, Keidar Z. Correlation between incidental FDG PET/CT colorectal observations and endoscopic and histopathological results. Oncol Lett. 2014;7:479–82.
4. Kaneko K, Sadashima E, Irie K, Hayashi A, Masunari S, Yoshida T, et al. Assessment of FDG retention differences between the FDG-avid benign pulmonary lesion and primary lung cancer using dual-time-point FDG-PET imaging. Ann Nucl Med. 2013;27:392–9.
5. d'Abadie P, Gheysens O, Lhommel R, Jamar F, Kirchgesner T, Mazzeo F, et al. Diagnostic superiority of Dual-Time point [18F]FDG PET/CT to differentiate malignant from benign soft tissue tumors. Diagnostics. 2023;13:3202.
6. Lee SW, Kim S-J. Is delayed image of 18F-FDG PET/CT necessary for mediastinal lymph node staging in Non-Small cell lung cancer patients?? Clin Nucl Med. 2022;47:414–21.
7. Sasada S, Masumoto N, Suzuki E, Sueoka S, Goda N, Kajitani K, et al. Prediction of biological characteristics of breast cancer using dual-phase FDG PET/CT. Eur J Nucl Med Mol Imaging. 2019;46:831–7.
8. Sa R, Zhao H-G, Dai Y-Y, Guan F. The role of dual time point PET/CT for distinguishing malignant from benign focal 18F-FDG uptake duodenal lesions. Med (Baltim). 2018;97:e12521.
9. Kelloff GJ, Hoffman JM, Johnson B, Scher HI, Siegel BA, Cheng EY, et al. Progress and promise of FDG-PET imaging for cancer patient management and oncologic drug development. Clin Cancer Res. 2005;11:2785–808.
10. Cysouw MCF, Golla SVS, Frings V, Smit EF, Hoekstra OS, Kramer GM, et al. Partial-volume correction in dynamic PET-CT: effect on tumor kinetic parameter Estimation and validation of simplified metrics. EJNMMI Res. 2019;9:12.
11. Phelps ME, Huang SC, Hoffman EJ, Selin C, Sokoloff L, Kuhl DE. Tomographic measurement of local cerebral glucose metabolic rate in humans with (F-18)2-fluoro-2-deoxy-D-glucose: validation of method. Ann Neurol. 1979;6:371–88.
12. Tsuchida T, Demura Y, Sasaki M, Morikawa M, Umeda Y, Tsujikawa T et al. Differentiation of histological subtypes in lung cancer with 18F-FDG-PET 3-point imaging and kinetic analysis.

13. Lee JH, Lee WA, Park SG, Park DK, Namgung H. Relationship between Dual-Time point FDG PET and immunohistochemical parameters in preoperative colorectal cancer: preliminary study. Nucl Med Mol Imaging. 2012;46:48–56.
14. Higashi T, Saga T, Nakamoto Y, Ishimori T, Mamede MH, Wada M, et al. Relationship between retention index in dual-phase (18)F-FDG PET, and hexokinase-II and glucose transporter-1 expression in pancreatic cancer. J Nucl Med. 2002;43:173–80.
15. Kashiwagi K, Nakazato Y, Arai M, Iwasaki E, Naganuma M, Inoue N, et al. Limited identification of Dual-time-point positron emission tomography/computed tomography in advanced colorectal neoplasms. Intern Med. 2017;56:1287–92.
16. Zhang X, Ogihara T, Zhu M, Gantumur D, Li Y, Mizoi K, et al. Effect of Metformin on 18F-fluorodeoxyglucose uptake and positron emission tomographic imaging. Br J Radiol. 2022;95:20200810.
17. Steenkamp DW, McDonnell ME, Meibom S. Metformin May be associated with false-negative cancer detection in the Gastrointestinal tract on PET/CT. Endocr Pract. 2014;20:1079–83.
18. Peng J, He Y, Xu J, Sheng J, Cai S, Zhang Z. Detection of incidental colorectal tumours with 18F-labelled 2-fluoro-2-deoxyglucose positron emission tomography/computed tomography scans: results of a prospective study. Colorectal Dis. 2011;13:e374–378.
19. Abouzied MM, Crawford ES, Nabi HA. 18F-FDG imaging: pitfalls and artifacts. J Nucl Med Technol. 2005;33:145–55. quiz 162–3.

Publisher's note