Preliminary study comparing diffuse gastric FDG uptake and gastritis

Seiei YASUDA, Masahiko TAKECHI, Kazuhiro ISHIZU, Akira TANAKA, Yuji MAEDA, Toshiyuki SUZUKI, Sotaro SADAHIRO, Masahiro OHTA*, Masayoshi ITOH*, and Hiroyasu MAKUUCHI

Department of Surgery, Tokai University School of Medicine
**Depatment of Internal Medicine, Yotsuya Medical Cube*

(Received May 14, 2007; Accepted September 19, 2008)

Diffuse high FDG uptake in the stomach is occasionally observed on positron emission tomography (PET) images. Some PET oncologists believe this to be physiologic uptake, but the exact cause is undetermined. We retrospectively compared PET images and endoscopic findings to examine the relation between diffuse gastric FDG uptake and gastritis. From September to December 2005, 113 individuals (68 men and 45 women), aged 52 ± 12 years, underwent both gastrofiberscopy and PET/computed tomography on the same day as part of a cancer screening program. Gastric FDG uptake was visually evaluated on PET images and classified as low, moderate, or high. Gastritis was classified as mild, moderate, or severe. For each screenee, the degree of FDG uptake was compared with the severity of gastritis. FDG uptake was low, moderate, and high in 64, 31, and 18 screenees, respectively. Gastritis was mild, moderate, and severe in 59, 44, and 10 screenees, respectively. A significant relation was observed between the degree of FDG uptake and the degree of gastritis ($p<0.0001$). High FDG uptake was observed significantly more often in the upper half of the stomach than in the lower half ($p<0.0001$). Similarly, gastritis was observed significantly more often in the upper half of the stomach ($p=0.005$). A significant relation was observed between the degree of FDG uptake and the severity of gastritis in both the upper ($p<0.0001$) and lower ($p=0.01$) portions. In conclusion, the significant relation we found between the degree of FDG uptake and the severity of gastritis suggests that gastritis is a major cause of diffuse FDG uptake in the stomach.

Key words: Positron emission tomography (PET), ^{18}F-Fluorodeoxyglucose (FDG), Gastritis, Glucose metabolism, Physiologic uptake

INTRODUCTION

Positron emission tomography (PET) with ^{18}F-fluorodeoxyglucose (FDG) has been increasingly used in the diagnosis of various cancers. Malignant tumors with accelerated glucose metabolism are depicted as high FDG accumulation. However, accelerated glucose metabolism is not specific to malignant tumors. High physiologic FDG uptake [1–3] and high FDG uptake in some benign lesions [4, 5] are well known. Diffuse high FDG uptake in the stomach is occasionally observed on PET images. Some PET oncologists believe this to be physiologic uptake [6, 7] although the exact cause of the uptake is unknown. We are collaborating with an institution where PET/computed tomography (CT) is used for cancer screening. Screenees undergo gastrofiberscopy and PET/CT on the same day. Not a few indivisuals with diffuse gastric FDG uptake on PET images were shown to have gastritis upon endoscopy. This prompted us to compare PET images and endoscopic findings to examine the relation between gastric FDG uptake and gastritis.

SUBJECTS AND METHODS

From September to December 2005, 113 individuals (68 men and 45 women), aged 52±12 years, underwent both gastrofiberscopy and PET/CT on the same day as part of a cancer screening program. Endoscopy was performed by one of two endoscopists (M.O. or M.I.) just prior to the PET/CT study. Thirty to 60 minutes after gastrofiberscopy, 200 MBq of FDG was injected, and 60 minutes later, PET/CT scanning was performed (Discovery ST: GE Healthcare, Milwaukee, WI, USA).

Gastritis was diagnosed when superficial gastritis, erosive gastritis, or hemorrhagic gastritis was seen endoscopically. For each screenee, the severity of gastritis was retrospectively evaluated and classified as mild, moderate, or severe (Fig. 1a).

PET images were retrospectively evaluated by one author (S.Y.). The degree of gastric FDG uptake was visually evaluated and classified as low, moderate, or high. Low uptake was defined as gastric FDG uptake that was lower than hepatic FDG uptake; moderate uptake was defined as gastric FDG uptake that was almost equal to hepatic FDG uptake; and high uptake was defined as gastric FDG uptake that was higher than hepatic FDG uptake (Fig. 1b). For each screenee, the degree of gastric FDG uptake was compared to the severity of gastritis.

Statistical analyses were performed with the $\chi 2$ test. P-values of less than 0.05 were considered significant.

RESULTS

The degree of FDG uptake was low, moderate, and high in 64, 31, and 18 screenees, respectively (Table 1). The severity of gastritis was mild, moderate, and severe in 59, 44, and 10 screenees, respectively.

Seiei Yasuda, Department of Surgery, Tokai University School of Medicine, 143 Shimokasuya, Isehara, Kanagawa, 259-1193, Japan
Phone: 0463-93-1121, FAX: 0465-95-6491 E-mail: yasuda@is.icc.u-tokai.ac.jp

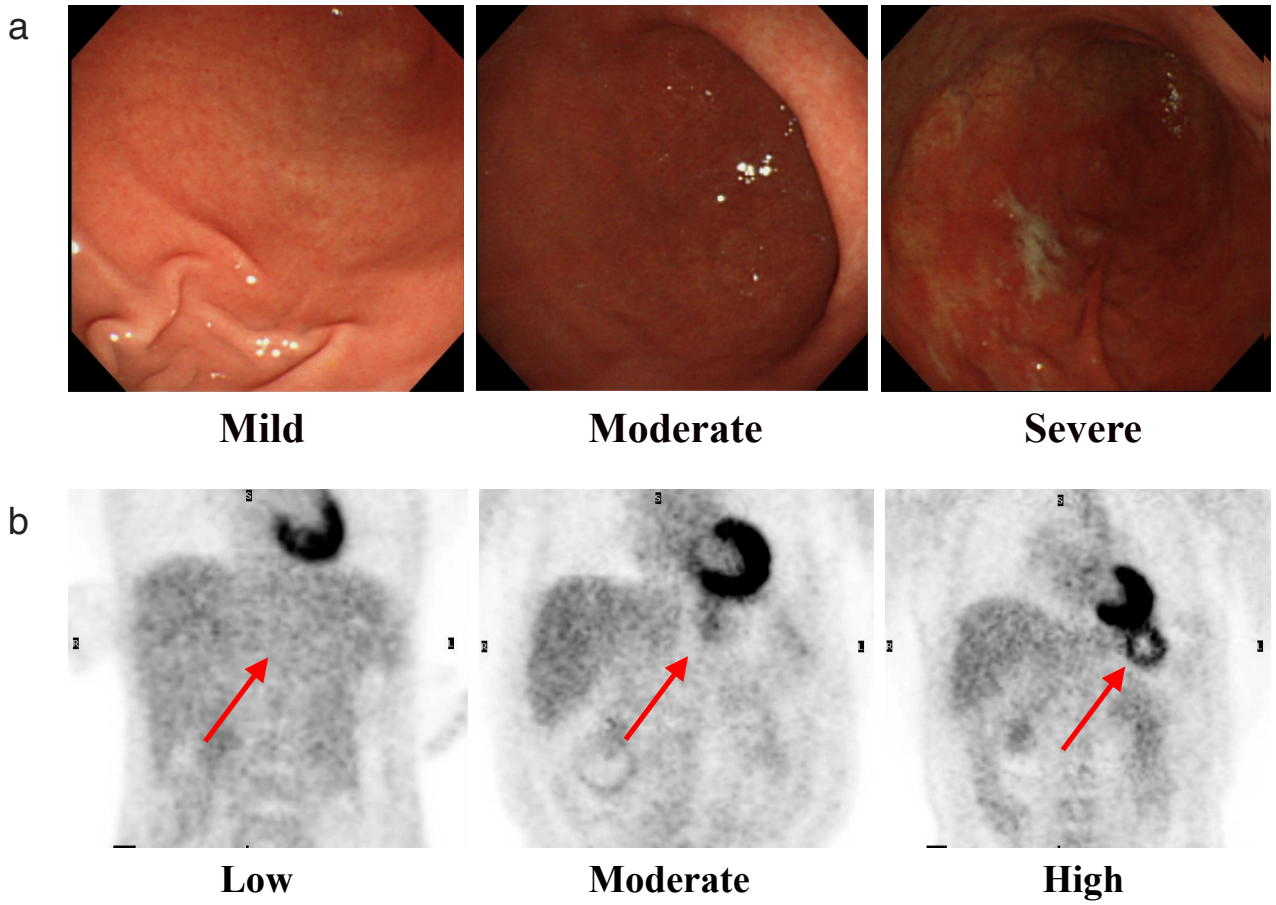

Fig. 1. Classification of the severity of gastritis and the degree of gastritis. (a) The severity of gastritis was classified as mild, moderate, or severe according to the endoscopic appearance. (b) The degree of FDG uptake on PET images was classified visually as low, moderate, or high.

Table 1 The degree of FDG uptake in relation to the severity of gastritis

Gastritis	FDG uptake Low	Moderate	High
Mild	50	6	3
Moderate	12	23	9
Severe	2	2	6

Number of subjects is shown.

High FDG uptake was observed in 18 of the total 113 screenees (16%). Fifteen of the 18 (83%) screenees had moderate to severe gastritis; 3 of the 18 (17%) screenees had no endoscopic abnormality. Severe gastritis was observed in 10 of the 113 screenees (9%). Eight of these 10 screenees showed moderate to high FDG uptake; the other 2 showed insignificant FDG uptake. In many cases, however, the degree of FDG uptake correlated with the severity of gastritis. A significant relation was observed between the degree of FDG uptake and the degree of gastritis ($p<0.0001$). A typical case is shown in Fig. 2.

The degree of FDG uptake was compared between the upper and lower portions of the stomach (Table 2a). Low, moderate, and high FDG uptake was observed in the upper portion in 64, 32, and 17 screenees, and in the lower portion in 90, 14, and 7 screenees. High FDG uptake was observed significantly more often in the upper half of the stomach than in the lower half ($p<0.0001$).

Similarly, the degree of gastritis was compared between the upper and lower halves of the stomach (Table 2b). Mild, moderate, and severe gastritis was observed in the upper half in 66, 38, and 9 screenees, retrospectively, and in the lower half in 87, 21, and 3 screenees, respectively. Gastritis was observed significantly more often in the upper half of the stomach than in the lower half ($p=0.005$).

The degree of FDG uptake and the degree of gastritis were compared for each half (Table 3a, b). A significant relation was observed between the degree of FDG uptake and the severity of gastritis in both the upper half ($p<0.0001$) and lower half ($p=0.01$).

Although seven screenees underwent biopsy just prior to PET studies, no effects were observed on the PET images.

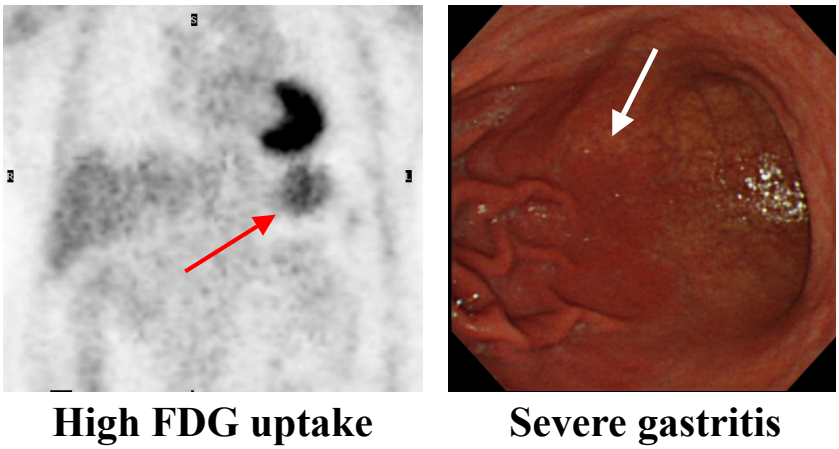

Fig. 2. Sixty-seven year-old man showed high FDG uptake and severe gastritis in the upper portion of the stomach.

Table 2a The degree of FDG uptake in the upper and lower portions of the stomach

	Low	Moderate	High
Upper	64	32	17
Lower*	90	14	7

Number of subjects is shown.
* Two subjects had undergone distal gastrectomy.

Table 2b The severity of gastritis in the upper and lower portions of the stomach

	Mild	Moderate	Severe
Upper	66	38	9
Lower*	87	21	3

Table 3 The degree of FDG uptake in relation to the severity of gastritis in the upper and lower portions of the stomach

	Gastritis	Low	FDG uptake Moderate	High
Upper half	*Mild*	52	11	3
	Moderate	10	19	9
	Severe	2	2	5

	Gastritis	Low	FDG uptake Moderate	High
Lower half *	*Mild*	77	8	2
	Moderate	11	6	4
	Severe	2	0	1

Number of subjects is shown.
* Two subjects had undergone distal gastrectomy.

DISCUSSION

Increased FDG uptake in the stomach is frequently observed upon PET study, and it is noted as non-pathologic, non-specific, or physiologic uptake [1]. However, the exact cause is unknown. Koga et al [7], in their study of 22 patients without any gastric lesions, assumed that gastric FDG uptake is physiologic uptake. They hypothesized that FDG uptake is caused by parietal cells in the mucosal layer that contain large numbers of mitochondria and facilitate increased glucose metabolism.

Gastritis is a term used to describe a group of conditions resulting from different causes [8]. In the present study, gastritis was defined as inflammation of the gastric mucosa (superficial gastritis or erosion) or the presence of hemorrhage. Gastric mucosal atrophy (atrophic gastritis) was not included. Our study

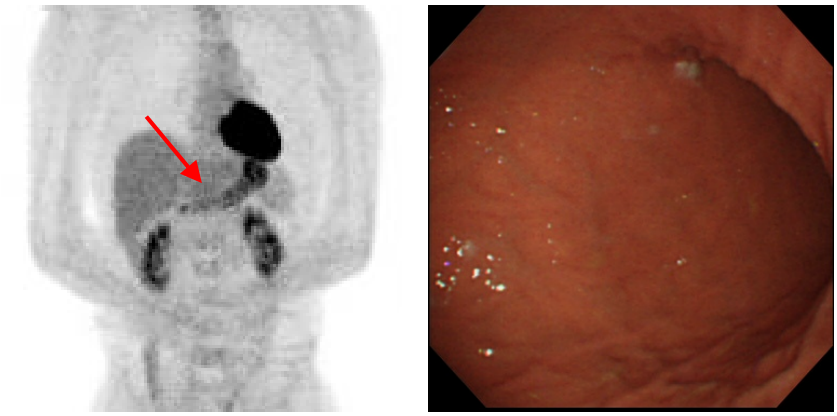

Fig. 3. PET images of a 43-year-old man. High FDG uptake in the entire stomach was observed, but gastritis was not observed.

included as many as 113 screenees, and a significant relation was recognized between FDG uptake and the endoscopic appearance of inflammation. The degree of FDG uptake on PET images was strongly related to the degree of inflammation observed endoscopically. Gastritis appeares to be an important cause of diffuse gastric FDG uptake.

There were exceptional cases. Three of the 18 (17%) screenees with high FDG uptake had no endoscopic abnormality. In two of these three screenees, the degree of gastritis was mild to moderate, and these cases were categorized as mild. In the remaining screenee, gastritis was absent (Fig 3). Peristalsis might explain the high FDG uptake in this exceptional case, but there is no scientific evidence of this. Two of the 10 screenees with severe gastritis showed insignificant FDG uptake. In one screenee, the FDG uptake was low to moderate, and this case was categorized as a case of low uptake. In another case, hemorrhage was present in the stomach but inflammation of the mucosa was not present (hemorrhagic gastropathy).

Koga et al. [7] compared FDG uptake in different regions of the stomach by dividing the stomach into the upper, middle, and lower areas and noted that the standardized uptake value (SUV) in the upper area was significantly higher than that in the lower area. Similarly, Wang et al [6] reported that the mean SUVs of the upper and middle stomach were higher than the mean SUV of the lower stomach. In our study also, significantly high FDG uptake was observed in the upper half of the stomach (moderate and high, 43%) compared to that in the lower half (18%). In addition, we noticed that gastritis was more prevalent in the upper half than in the lower half and that there was significant correlation between the degree of FDG uptake and the degree of gastritis in both the upper and lower halves of the stomach.

Our study had several limitations that warrant comment. First, diabetic persons were not excluded from the study although the disease may affect glucose metabolism of the stomach. Second, scopolamine butylbromide or glucagon was used intravenously in all screenees as premedication for endoscopy. These medications were administered 30 to 60 minutes prior to FDG injection. Because these medications suppress gastric motility, they might also affect FDG uptake of the stomach. Third, the degree of FDG uptake was categorized by visual evaluation. Objective semi-quantitative evaluation based on SUVs might be more reliable than visual evaluation. Fourth, we previously reported that gastric FDG uptake is related to H. pylori infection [9]. In the current study, however, we were not able to examine the relation between H. pylori infection and FDG uptake. Because most of histological gastritis occur in conjunction with H. pylori infection, further studies are warranted to scrutinize relationship between H. pylori infection and gastric FDG uptake. Fifth, chronic gastritis is currntly classified according to the Sydney System [10] in which biopsy specimens should be taken for assessing inflammatory cells in gastric musosa. In this stuy, however, biopsy was not performed and terminology of gastritis was used based on endoscopic appearance not on the Sydney System. Endoscopically diagnosed gastritis such as superficial gastritis, erosion or the presence of hemorrhages are not necessarily in accordance with histological gastritis.

In conclusion, the significant relationship we found between the degree of FDG uptake and the severity of gastritis suggests that gastritis is a major cause of diffuse FDG uptake in the stomach. Diffuse high FDG uptake was observed in 16% of our subjects, and 83% of these subjects showed moderate to severe gastritis endoscopically. Because appropriate therapy for gastritis depends on the symptoms, medical treatment or endoscopic examination to confirm the presence of gastritis is recommended when diffuse high FDG uptake is observed on PET images and symptoms of gastritis are present.

This study was presented at the 53rd annual meeting of the Society of Nuclear Medicine (June 2006, San Diego).

REFERENCES

1) de Groot M, Meeuwis APW, Kok PJM, Corstens FHM, Oyen WJG. Influence of blood glucose level, age and fasting period on non-pathological FDG uptake in heart and gut. Eur J Nucl Med Mol Imaging 2005; 32: 98–101.
2) Yasuda S, Takahashi W, Takagi S, Fujii H, Ide M, Shohtsu A. Factors influencing physiological FDG uptake in the intestine. Tokai J Exp Clin Med 1998; 23: 241–244.
3) Nakahara T, Fujii H, Ide M, Nishiumi N, Takahashi W, Yasuda S,

Shohtsu A, Kubo A. FDG uptake in the morphologically normal thymus: comparison of FDG positron emission tomography and CT. Br J Radiol 2001; 74: 821–824.
4) Yasuda S, Fujii H, Nakahara T, Nishiumi N, Takahashi W, Ide M, Shohtsu A. 18F-FDG PET detection of colonic adenomas. J Nucl Med 2001; 42: 989–992.
5) Yasuda S, Shohtsu A, Ide M, Takagi S, Takahashi W, Horiuchi M. Chronic thyroiditis: diffuse uptake of FDG at PET. Radiology 1998; 207: 775–778.
6) Wang Y, Chiu E, Rosenberg J, Gambhi SS. Standardized upatake value atlas: characterization of physiological 2-deoxy-2-[18F] fluoro-D-glucose uptake in normal tissues. Mol Imaging Biol 2007; 9: 83–90.
7) Koga H, Sasaki M, Kuwabara Y, Hiraka K, Nakagawa M, Abe K. Kaneko K, Hayashi K, Honda H. An analysis of the physiological FDG uptake pattern in the stomach. Ann Nucl Med 2003; 17: 733–738.
8) Genta RM. Gastritis and gastropathy. In: Yamada T, eds. Textbook of Gastroenterology. Philadelphia, PA: Lippincott Williams & Wilkins; 2003: 1394–1415.
9) Fujii H, Yasuda S, Ide M, Takahashi W, Mochizuki Y, Nakahara T, Shohtsu A, Kubo A. Factors influencing nonpathological FDG uptake in various organs. In: Tamaki N, et al. eds, Positron Emission Tomography in the Millennium, Elsevoer Science B.V., Amsterdam; 2000: 213–219.
10) Dixon MF, Genta RM, Yardley JH, Correa P, et al. Classification and grading of gastritis. The updated Sydney System. Am J Surg Pathol. 1996; 20(10): 1161–1181.