Clinical role of ^{18}F-FDG PET for initial staging of patients with extrahepatic bile duct cancer

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Abstract. In extrahepatic bile duct cancer, preoperative evaluation is important because only surgical excision of all detectable tumours is associated with improvement in 5-year survival. However, morphological imaging techniques, including computed tomography (CT), are still insufficient for accurate staging. The purpose of this study was to assess the additional value, in relation to CT, of 2-[^{18}F]fluoro-2-deoxy-D-glucose positron emission tomography (^{18}F-FDG PET) for the evaluation of extrahepatic bile duct cancer. Thirty patients with extrahepatic bile duct cancer underwent both ^{18}F-FDG PET and CT for initial staging. The results of the two modalities for evaluation of primary tumours and regional lymph nodes were compared with the final diagnoses based on pathological or clinical findings. The primary tumours were interpreted as malignant on the basis of CT in 24 (80%) of the patients, while ^{18}F-FDG PET revealed increased ^{18}F-FDG uptake in 18 (60%) of them. On the other hand, ^{18}F-FDG PET showed focal accumulation of ^{18}F-FDG in the bile duct in three of the six patients with equivocal findings on CT. The sensitivity, specificity and accuracy of CT for regional lymph node metastases were 54%, 59% and 57%, while those of ^{18}F-FDG PET were 38%, 100% and 73%, respectively. The specificity of ^{18}F-FDG PET for regional lymph node metastases was significantly higher than that of CT (P<0.01). Of 14 patients with N1 or N2 disease diagnosed by CT, only seven (50%) had a final diagnosis of regional lymph node metastasis. In these 14 patients, ^{18}F-FDG PET accurately evaluated the N component of the disease in 12 patients (86%). In conclusion, in the initial staging of patients with extrahepatic bile duct cancer, ^{18}F-FDG PET offers additional value in relation to CT in evaluating both the primary tumour and regional lymph nodes.

Keywords: Bile duct cancer – FDG – Positron emission tomography – Computed tomography

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Introduction

Bile duct cancer is a rare malignancy that develops from the extrahepatic bile duct. At present, only surgical excision of all detectable tumours is associated with improvement in 5-year survival [1, 2]. Morphological imaging techniques such as computed tomography (CT) or magnetic resonance imaging are essential modalities for preoperative evaluation of tumour extension and resectability [2, 3]. CT is used as the principal imaging method for diagnostic examination of patients with bile duct cancer and CT findings have been well described [4, 5, 6, 7, 8, 9]. However, these morphological imaging techniques are not sufficient for accurate diagnosis, and generally, invasive procedures such as percutaneous or endoscopic biopsy are performed to obtain conclusive diagnosis [2, 6].

Positron emission tomography (PET) utilising the glucose analogue 2-[^{18}F]fluoro-2-deoxy-D-glucose (FDG) has gained acceptance in clinical oncology for the detection of various tumours [10, 11, 12]. In particular, there are many studies reporting the value of this method for the assessment of various cancers of the abdominal area, such as pancreatic carcinoma, because ^{18}F-FDG

PET provides biochemical information that is not acquired by other imaging modalities [13, 14]. With regard to biliary tract cancers, on the other hand, only a few reports have indicated increased ^{18}F-FDG uptake in gallbladder carcinoma and cholangiocarcinoma [15, 16]. To the best of our knowledge, however, the diagnostic value of ^{18}F-FDG PET in patients with extrahepatic bile duct cancer has not been well evaluated in comparison with CT. The purpose of this study was to assess the additional value of ^{18}F-FDG PET, in relation to CT, for evaluation of extrahepatic bile duct cancer.

Materials and methods

Patients. The study group comprised 30 patients (21 male, 9 female; mean age 68 years; age range 32–82 years) with bile duct cancer who were examined by both CT and ^{18}F-FDG PET for initial staging between March 1999 and August 2001 in our institution. Written informed consent was obtained from all of the patients before the PET study, which was approved by the Hokkaido University Ethical Committee. The definition of extrahepatic bile duct cancer was based on the criteria established by Japanese Society of Biliary Surgery [17] and the staging criteria were based on the standard TNM classification (1997).

Computed tomography. CT of the upper abdomen was performed at our institution using Aquillion (Toshiba) or Somatom Plus 4 (Siemens). All of the patients underwent two-phase (arterial- and portal-dominant) spiral CT. Scanning was performed at 120 kVp and 280 mAs. We injected 90 ml of the nonionic contrast material iopromide at 300 mg I/ml using an automated injector (Zto Enhance A-50; Nemoto Kyorindo Co., Tokyo, Japan) at a rate of 3.5 ml/s. Scanning in the arterial and portal venous phases was started at 25 s and 60 s, respectively. Images were reconstructed at 3-mm intervals. All of the CT scans were interpreted in a routine clinical manner by experienced radiologists who had no knowledge of the PET findings. The CT findings in respect of primary tumours were classified as “malignant” or “equivocal” based on the written reports. The CT findings for primary tumours were classified as malignant if a mass with direct invasion of neighbouring structures or apparent metastasis to the liver was present in the hepatobiliary tract. In addition, CT findings were classified as malignant when there was apparent thickening and contrast enhancement of the wall of the extrahepatic bile duct, or an intraluminal mass with contrast enhancement in the extrahepatic bile duct. The CT findings were classified as equivocal if they did not conclusively indicate a malignant tumour, or if no abnormality was detected in the hepatobiliary tract, or if the malignant tumour was considered difficult to identify because of the presence of an artefact due to the drainage tube in the bile duct. The CT findings in respect of regional lymph node metastases were classified into three categories: “malignant”(size in the short axis ≥1 cm), “equivocal” (<1 cm), or “no metastasis”.

^{18}F-FDG PET. Whole-body ^{18}F-FDG PET imaging was performed with an ECAT EXACT 47 scanner (Siemens-CTI, Knoxville, Tenn.) within 3 weeks after CT. This scanner provides 47 contiguous image planes with 3.375-mm plane spacing and an in-plane resolution of 6.6 mm. Before the PET study, all of the patients fasted for at least 6 h. Serum glucose levels were checked in all of the patients before administration of ^{18}F-FDG. Static emission scans from the base of the skull to the lower pelvis were obtained at 60 min after ^{18}F-FDG administration using the three-dimensional acquisition mode for 2 min per bed position. Thereafter, transmission scans using externally rotating germanium-68 rod sources were performed for attenuation correction. Emission data were reconstructed by filtered back-projection with a Hanning filter. Moreover, attenuation-corrected data were reconstructed iteratively using an ordered subset expectation maximisation algorithm.

Image processing and reconstruction were performed on a SUN workstation. ^{18}F-FDG PET images were displayed as coronal, sagittal and transaxial slices, and a whole-body image was also displayed as a set of projection images for visual interpretation. Both attenuation-corrected and non-attenuation-corrected whole-body ^{18}F-FDG PET images were interpreted by a consensus of two experienced nuclear medicine physicians, who were blind to the CT images. Attenuation-corrected images were used mainly for diagnosis in the abdominal area. The ^{18}F-FDG PET findings regarding primary tumours or metastases were classified into “positive” or “negative”. A positive finding was defined as the presence of abnormal accumulation, the focus of which was detectable visually and was greater than the surrounding background. The ^{18}F-FDG uptake within lesions was quantified by determining the mean activity with a circular region of interest (ROI) of 1 cm in diameter. After correction for radioactive decay, the ROI was semiquantitatively analysed by computing a standard uptake value (SUV) according to the following formula: SUV = mean ROI activity (MBq/ml)/injected dose (MBq)/body weight (g). To determine the location of abnormal ^{18}F-FDG accumulation, the PET images were finally compared with the CT images. A negative finding was defined as the absence of abnormal ^{18}F-FDG accumulation in the hepatobiliary tract.

Analysis. The results of CT and ^{18}F-FDG PET with respect to primary tumours and regional lymph node metastases were compared with the final diagnoses based on findings of surgery, endoscopic biopsy or clinical follow-up for more than 6 mouths. The results of ^{18}F-FDG PET and CT for regional lymph nodes were classified into true positive, true negative, false positive or false negative with respect to the final diagnoses. From these data, the sensitivity, specificity and accuracy of the two methods were calculated. The differences in the results were statistically analysed using the chi-square test. A value of $P<0.05$ was considered statistically significant.

Results

Primary tumours

The final diagnoses of primary tumours were based on the findings of surgery (n=24) or endoscopic or percutaneous biopsy (n=6, patients 1, 3, 4, 9, 13 and 21). Adenocarcinoma was the most common histological finding (28 patients); in the remaining two patients, the diagnoses were squamous cell carcinoma (patient 5) and adenosquamous carcinoma (patient 26). The histopathological tumour stage in 24 patients with resectable tumour was pT1 in three patients, pT2 in 11 and pT3 in ten. Surgical resection of primary tumours in six patients was not performed because of widespread tumour (n=5) or the presence of liver metastasis (n=1).

Table 1. Results in respect of primary tumours

Pt. no.	CT finding	^{18}F-FDG PET		Final diagnosis	
		Finding	SUV	Pathology	pT stage
1	Malignant	Pos.	8.3	Adenocarcinoma	–
2	Malignant	Pos.	8.0	Adenocarcinoma	pT3
3	Malignant	Pos.	7.2	Adenocarcinoma	–
4	Malignant	Pos.	6.1	Adenocarcinoma	–
5	Malignant	Pos.	5.9	Squamous cell carcinoma	pT3
6	Malignant	Pos.	5.7	Adenocarcinoma	pT3
7	Malignant	Pos.	4.5	Adenocarcinoma	pT3
8	Malignant	Pos.	4.3	Adenocarcinoma	pT1
9	Malignant	Pos.	4.3	Adenocarcinoma	–
10	Malignant	Pos.	3.3	Adenocarcinoma	pT2
11	Malignant	Pos.	2.9	Adenocarcinoma	pT2
12	Malignant	Pos.	2.8	Adenocarcinoma	pT2
13	Malignant	Pos.	3.9	Adenocarcinoma	–
14	Malignant	Pos.	2.4	Adenocarcinoma	pT2
15	Malignant	Pos.	2.0	Adenocarcinoma	pT3
16	Malignant	Neg.	–	Adenocarcinoma	pT3
17	Malignant	Neg.	–	Adenocarcinoma	pT1
18	Malignant	Neg.	–	Adenocarcinoma	pT3
19	Malignant	Neg.	–	Adenocarcinoma	pT2
20	Malignant	Neg.	–	Adenocarcinoma	pT2
21	Malignant	Neg.	–	Adenocarcinoma	–
22	Malignant	Neg.	–	Adenocarcinoma	pT3
23	Malignant	Neg.	–	Adenocarcinoma	pT3
24	Malignant	Neg.	–	Adenocarcinoma	pT1
25	Equivocal	Pos.	4.0	Adenocarcinoma	pT2
26	Equivocal	Pos.	2.9	Adenosquamous carcinoma	pT2
27	Equivocal	Pos.	2.5	Adenocarcinoma	pT2
28	Equivocal	Neg.	–	Adenocarcinoma	pT3
29	Equivocal	Neg.	–	Adenocarcinoma	pT2
30	Equivocal	Neg.	–	Adenocarcinoma	pT2

Table 1 summarises the results of CT and ^{18}F-FDG PET for the primary tumours of the 30 patients studied. The primary tumours were interpreted as malignant in 24 (80%) of the patients by CT. On the other hand, ^{18}F-FDG PET revealed increased ^{18}F-FDG uptake in the hepatobiliary tract, which was regarded as a positive finding, in 18 (60%) of the 30 patients (Figs. 1, 2). The SUV of these lesions ranged from 2.0 to 8.3 (mean 4.5). ^{18}F-FDG PET failed to identify the primary tumour in the remaining 12 patients.

The positive rates obtained with ^{18}F-FDG PET for the various histopathological tumour stages in 24 patients with resectable tumours are shown in Table 2. No difference was evident between the positive ^{18}F-FDG PET rates for pT2 and pT3.

The findings of CT and ^{18}F-FDG PET with respect to primary tumours are summarised in Table 3 for the purpose of comparison. Of 13 primary tumours in which the CT finding was a tumoural mass (1.0–6.7 cm) in the bile duct, 11 (85%) were visualised by ^{18}F-FDG PET. On the other hand, when CT visualised primary tumours as enhanced bile duct wall thickening (n=11), the rate of detection by ^{18}F-FDG PET was significantly lower (36%) (P<0.05). Surgical and histopathological analyses confirmed extrahepatic bile duct cancer to be of the infiltrative type in ten of these 11 patients.

In six patients the CT results were equivocal because CT showed a slight smooth thickening of the extrahepatic bile duct wall, which was considered insufficient for the diagnosis of malignancy (n=2) (Fig. 3), or CT did not detect a tumour because of the presence of an artefact due to the drainage tube in the bile duct (n=4). The focal accumulation of ^{18}F-FDG in the bile duct indicated a positive finding in three of these six patients (Fig. 3). Surgical and histopathological analyses confirmed the extrahepatic bile duct cancer to be of the infiltrative type in five of the six patients.

Regional lymph node metastases

In 13 of the 30 patients with bile duct cancer, regional lymph node metastases were detected by surgical exploration with histological verification (n=9), surgical findings (n=2, patients 9 and 13) or clinical follow-up (n=2, patients 1 and 4) to confirm the increase in size of the

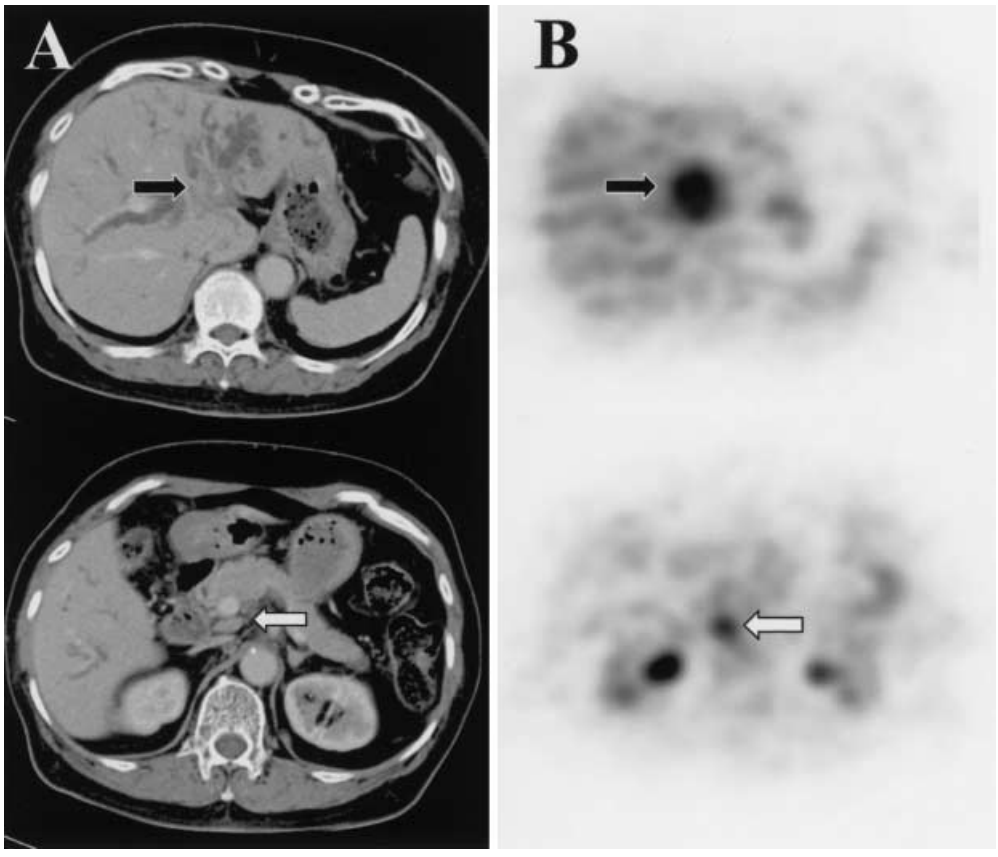

Fig. 1A, B. A 73-year-old woman with perihilar bile duct cancer (patient 2). **A** Contrast-enhanced CT imaging shows intrahepatic biliary dilatation and an irregular low-attenuating mass (*black arrows*) with a diameter of 3.3 cm at the level of the hilum, interpreted as a malignant tumour. CT also shows peripancreatic lymph node swelling interpreted as malignant (size 2.0 cm) (*white arrow*). **B** Axial ^{18}F-FDG PET images at the same level as those in **A** reveal intense focal accumulation of ^{18}F-FDG in the hilum of the liver, interpreted as a positive finding (SUV=8.0) (*black arrow*). In addition, there is abnormal accumulation of ^{18}F-FDG (*white arrow*) and peripancreatic lymph node metastasis was suspected. The final diagnosis, which was obtained by surgical exploration with histological verification, was lymph node metastasis

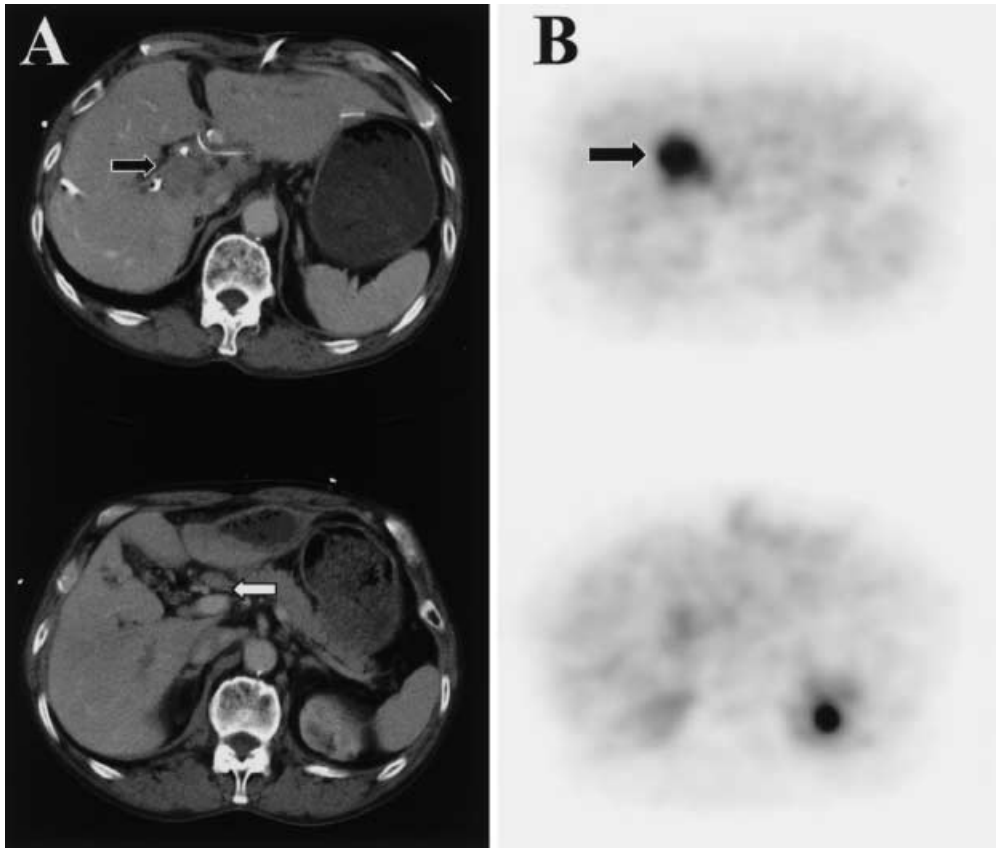

Fig. 2A, B. A 65-year-old man with perihilar bile duct cancer (patient 5). **A** Contrast-enhanced CT imaging shows an irregular low-attenuating mass (*black arrow*) with a diameter of 3.0 cm at the level of the hilum, interpreted as a malignant tumour. CT also shows lymph node swelling in the hepatoduodenal ligament (size 2.2 cm) (*white arrow*). **B** Axial ^{18}F-FDG PET images at the same level as those in **A** reveal intense focal accumulation of ^{18}F-FDG in the hilum of the liver as a positive finding (SUV=5.9) (*black arrow*), while there is no abnormal accumulation of ^{18}F-FDG that would be indicative of lymph node metastasis (inferior image). The final diagnosis, which was obtained by surgical exploration with histological verification, was absence of lymph node metastasis

Table 2. ^{18}F-FDG PET results and histopathological tumour stage in 24 patients with resectable tumour

pT	No.	^{18}F-FDG PET positive rate
pT1	3	33% (1/3)
pT2	11	64% (7/11)
pT3	10	50% (5/10)

Table 3. Comparison of CT and ^{18}F-FDG PET findings with respect to primary tumours

CT findings		No.	^{18}F-FDG PET positive rate
Malignant	Tumoural mass in bile duct	13	85% (11/13)*
	Enhanced thickening of bile duct	11	36% (4/11)
Equivocal	Not detected due to artefact?	4	50% (2/4)
	Focal thickning of bile duct?	2	50% (1/2

*P<0.05 (enhanced bile duct wall thickening on CT vs tumoural mass on CT)

lymph node by follow-up CT. In 15 of the remaining 17 patients, absence of regional lymph node metastases was confirmed by surgical exploration with histological verification. In the other two patients (nos. 3 and 21), disappearance of lymph node swelling was confirmed on follow-up CT; these patients received only palliative therapy. The results of evaluation of the diagnostic value of CT and ^{18}F-FDG PET with respect to regional lymph node metastases are shown in Tables 4 and 5. The sensitivity of CT for evaluating lymph node metastasis was 54% (7/13) and its specificity was 59% (10/17). The overall accuracy of CT was 57% (17/30). The sensitivity of ^{18}F-FDG PET was 38% (5/13) and its specificity, 100% (17/17). The overall accuracy of ^{18}F-FDG PET was 73% (22/30). The specificity of ^{18}F-FDG PET with respect to regional lymph node metastases was significantly higher than that of CT (P<0.01). There was no statistical difference in the sensitivity and accuracy of the two modalities. Of 14 patients with N1 or N2 disease on CT, only seven (50%) had a final diagnosis of regional lymph node metastasis. ^{18}F-FDG PET accurately evaluated the N component of the disease in 12 of these 14 patients (86%) (Table 6; Figs. 1, 2). Among 16 patients with N0 disease on CT, both CT and ^{18}F-FDG PET missed regional lymph node metastases in six (Table 4). Thus, ^{18}F-FDG PET improved nodal staging of extrahepatic bile duct cancer with respect to CT alone in seven out of 30 patients studied (23%).

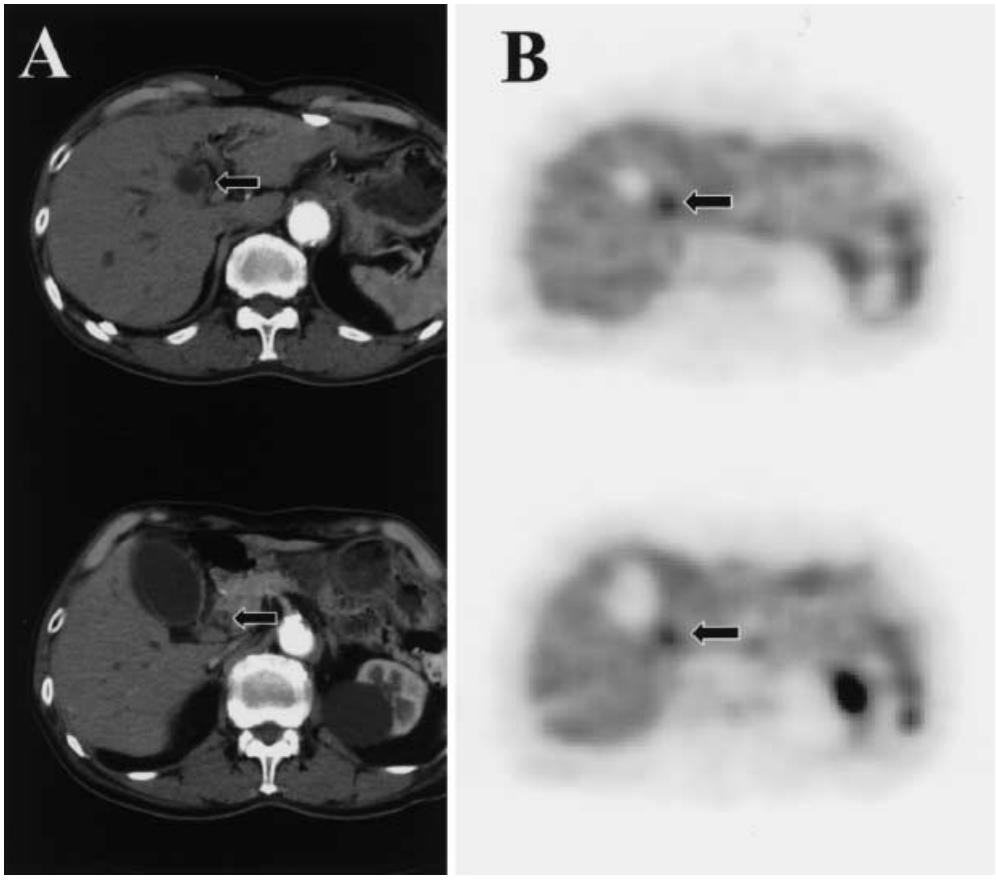

Fig. 3A, B. An 80-year-old man with perihilar bile duct cancer (patient 27). **A** Enhanced CT shows a slight smooth thickening of the extrahepatic bile duct wall that is difficult to identify as a malignant lesion or an inflammatory lesion and was thus interpreted as an equivocal finding. **B** Axial ^{18}F-FDG PET images at the same level as **A**, revealing focal accumulation of ^{18}F-FDG in the bile duct that was interpreted as a positive finding (SUV=2.5)

Table 4. Comparison of CT and ^{18}F-FDG PET findings with respect to regional lymph node metastases

Pt. no.	CT				^{18}F-FDG PET		Final diagnosis
	Finding	Location	Size (mm) *	Diagnosis	Finding	SUV	
1	Malignant	Peripancreatic	13	N2	Pos.	3.0	N2
2	Malignant	HDL, peripancreatic	20	N2	Pos.	3.5	pN2
4	Malignant	HDL, coeliac	10	N2	Pos.	2.3	N2
9	Malignant	HDL, peripancreatic	26	N2	Pos.	3.7	N2
13	Malignant	HDL	12	N1	Pos.	2.7	N1
8	Malignant	HDL, peripancreatic	20	N2	Neg.	–	pN2
22	Malignant	Periportal	25	N2	Neg.	–	pN2
5	Malignant	HDL	22	N1	Neg.	–	pN0
10	Malignant	Periportal	10	N2	Neg.	–	pN0
20	Malignant	HDL, peripancreatic	10	N2	Neg.	–	pN0
21	Malignant	HDL	14	N1	Neg.	–	N0
26	Malignant	HDL	13	N1	Neg.	–	pN0
28	Malignant	Periportal	15	N2	Neg.	–	pN0
29	Malignant	HDL	13	N1	Neg.	–	pN0
15	Equivocal	HDL	9	N0	Neg.	–	pN2
30	Equivocal	HDL	9	N0	Neg.	–	pN1
18	No	–	–	N0	Neg.	–	pN2
23	No	–	–	N0	Neg.	–	pN1
25	No	–	–	N0	Neg.	–	pN2
27	No	–	–	N0	Neg.	–	pN1
3	Equivocal	HDL	8	N0	Neg.	–	N0
6	Equivocal	HDL, peripancreatic	8	N0	Neg.	–	pN0
14	Equivocal	HDL	6	N0	Neg.	–	pN0
16	Equivocal	HDL, peripancreatic	8	N0	Neg.	–	pN0
19	Equivocal	HDL	9	N0	Neg.	–	pN0
7	No	–	–	N0	Neg.	–	pN0
11	No	–	–	N0	Neg.	–	pN0
12	No	–	–	N0	Neg.	–	pN0
17	No	–	–	N0	Neg.	–	pN0
24	No	–	–	N0	Neg.	–	pN0

Table 5. Comparison of CT and ^{18}F-FDG PET for the detection of regional lymph node metastases

	CT	^{18}F-FDG PET	*P*
Sensitivity	54% (7/13)	38% (5/13)	NS
Specificity	59% (10/17)	100% (17/17)	$P<0.01$
Accuracy	57% (17/30)	73% (22/30)	NS

NS, Not statistically significant

Table 6. ^{18}F-FDG PET results for 14 patients with N1 or N2 disease in CT

	Final diagnosis		Total
	N0	N1 or N2	
^{18}F-FDG PET			
N0	7	2	9
N1 or N2	0	5	5
Total	7	7	14

Discussion

Although there are a few reports indicating the value of ^{18}F-FDG PET in the diagnosis of biliary tract cancers [15, 16], the diagnostic role of ^{18}F-FDG PET for extrahepatic bile duct cancer has not been fully evaluated in comparison with CT. This study indicated that ^{18}F-FDG PET has an additional value, in relation to CT, for evaluation of primary tumours and lymph node metastases of extrahepatic bile duct cancer. In this study, ^{18}F-FDG PET could detect the primary tumours in three of six patients (50%) not found to have malignant tumours on CT. For regional lymph node metastases, the specificity of ^{18}F-FDG PET was significantly higher than that of CT. In addition, in comparison with CT alone, ^{18}F-FDG PET improved the nodal staging of extrahepatic bile duct cancer in seven out of 30 patients studied (23%).

One of the important roles of ^{18}F-FDG PET is differentiation of benign from malignant tumours such as solitary lung nodules or pancreatic masses [13, 14, 17]. In bile duct cancer, Keiding et al. [15] have reported the ability of ^{18}F-FDG PET to detect cholangiocarcinomas

as small as 1 cm in diameter in patients with primary sclerosing cholangitis. Kluge et al. [18] reported good sensitivity (92.3%), specificity (92.9%) and accuracy (92.6%) of ^{18}F-FDG PET for the detection of bile duct cancer. In comparison, we found the rate of detection of extrahepatic bile duct cancer by means of ^{18}F-FDG PET to be considerably lower. Although the reason for this discrepancy is not clear, patients' characteristics may have been one of the reasons. The 26 patients in the report of Kluge et al. [18] included eight with distant metastasis, nine with residual tumour after photodynamic therapy and two with recurrent tumour after surgery. Tumour extension was confirmed surgically in 11 patients (42%) in their study. In our study, ^{18}F-FDG PET was performed for initial staging in all patients and 24 patients (80%) underwent surgery for treatment. Only one patient had distant metastasis in the liver. In short, our patients were at earlier stages of bile duct cancer than those of Kluge et al. Our patients' characteristics are not uncommon for the initial diagnosis of extrahepatic bile duct cancer because the most frequent symptom of bile duct cancer is jaundice caused by bile duct obstruction due to local extension of the primary tumour; distant metastases are relatively infrequent and occur late in the course of development of extrahepatic bile duct cancer [2].

In this study, the rate of detection of primary tumours by ^{18}F-FDG PET was related to the shape of the tumour, not to the depth of tumour invasion. In 17 of the 30 patients the primary tumours showed no tumoural mass on CT, and these tumours were considered to be bile duct cancer of the infiltrative type. In fact, 15 of these 17 patients were confirmed to have bile duct cancer of the infiltrative type by surgical and histopathological analyses. According to Choi et al. [4], the appearance of extrahepatic bile duct cancer can be classified into three types: infiltrating, exophytic and polypoid. They reported that infiltrating tumours, which are the most common, are more difficult to detect by CT than exophytic or polypoid tumours [4]. Furthermore, it is difficult to interpret smooth wall thickening of the bile duct on CT, because several diseases, including bile duct cancer and cholangitis, have been reported to be associated with enhanced thickening of the bile duct [19]. In our series, CT failed to identify six of 17 infiltrating tumours. ^{18}F-FDG PET also did not identify 12 of 17 infiltrating tumours. The limited sensitivity of ^{18}F-FDG PET for detection of these lesions may be explained as follows: The activity in a small, narrow lesion is underestimated because of the partial volume effect, and the high physiological ^{18}F-FDG uptake in the liver and the intestine obscures lesions because of the limited spatial resolution of the PET camera. Careful evaluation is necessary in cases of bile duct cancer with no tumoural mass on CT. Generally, percutaneous or endoscopic retrograde cholangiography is the most important radiological procedure for assessing extrahepatic bile duct cancer [2]. Moreover, percutaneous or endoscopic biopsy is considered to provide conclusive diagnosis. However, these procedures are invasive and sometimes yield non-diagnosable tissues because of the desmoplastic nature of the lesion [2]. Although the ability of ^{18}F-FDG PET and CT to detect infiltrative tumours is limited, these modalities are non-invasive procedures. In addition, ^{18}F-FDG PET revealed three lesions that were equivocal on CT; therefore, ^{18}F-FDG PET has additional value compared with CT in detecting infiltrating tumours.

In our study, we compared findings of ^{18}F-FDG PET for the staging of regional lymph node metastasis with those of CT. CT is performed as the principal modality for evaluation of extrahepatic bile duct cancer, particularly with regard to regional lymph node metastasis [2]. However, Feydy et al. [6] reported that CT was not effective in the assessment of lymph node involvement. The differentiation of malignant involvement of lymph nodes by CT is dependent only on the size of the lymph nodes. However, it is well known that normal lymph node swelling may occur in the biliary drainage system even in the absence of biliary disease, and enlargement of upper abdominal lymph nodes can be caused by an inflammatory reaction [20]. ^{18}F-FDG PET can reveal malignant lymph nodes without compromising by relying morphological size criteria. Many investigators have shown that ^{18}F-FDG PET is more accurate than CT for evaluation of mediastinal lymph node metastases of non-small cell lung cancers [21]. The ranges of sensitivity, specificity and accuracy are 66%–100%, 81%–100% and 80%–100%, respectively [19]. In the case of bile duct cancer, Kluge et al. [18] reported low sensitivity (13%) of ^{18}F-FDG PET for regional lymph node metastases. Our findings were concordant with their results. However, they did not compare CT and ^{18}F-FDG PET findings with respect to regional lymph node metastases. In our study, the specificity of ^{18}F-FDG PET was significantly higher than that of CT. In addition, ^{18}F-FDG PET accurately evaluated the N component of the disease in 12 of 14 patients (86%) who were diagnosed as having N1 or N2 disease by CT. A final diagnosis of lymph node metastasis was made in only 7 of these 14 patients (50%). Thus, in comparison with CT, ^{18}F-FDG PET provides additional information in the evaluation of regional lymph node metastasis of bile duct cancer. On the other hand, the sensitivity of ^{18}F-FDG PET was only 38%, and no lymph node metastases could be detected in patients with equivocal or no lymph node metastases on CT. The cause of the low sensitivity of ^{18}F-FDG PET may be its limited spatial resolution, which precludes the detection of micrometastases.

Some limitations of our study should be mentioned. For the evaluation of nodal staging, node-by-node correlation between CT and ^{18}F-FDG PET was not performed, because determining the precise location of the lesion is difficult on PET images. Fusion images with combined CT and PET may be useful for this purpose and might

lead to more accurate nodal staging of extrahepatic bile duct cancer. Second, the value of ^{18}F-FDG PET for evaluating distant metastasis of bile duct cancer could not be determined in this study, because only one patient had distant metastasis in our series. Because our hospital is a tertiary hospital, our patient population might have been preselected as likely to be suitable for surgery, with patients having extensive progressive disease tending not to be referred to our hospital. Further studies are needed to evaluate the role of ^{18}F-FDG PET in detecting distant metastasis of bile duct cancer.

In conclusion, the results of our study suggest that although ^{18}F-FDG PET may not be ideal for detecting the infiltrating type of extrahepatic bile duct cancer, it has an additional value in relation to CT in evaluating primary lesions and regional lymph node metastases, and may be used for accurate staging of extrahepatic bile duct cancer.

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