A Case of Colon Cancer Detected by Carbon-11 Choline Positron Emission Tomography/Computed Tomography: An Initial Report

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[C-11] choline positron emission tomography ([C-11] choline PET) has been expected to be one of the new PET modalities similar to [F-18] fluorodeoxyglucose positron emission tomography (FDG-PET), which has spread worldwide as a gold standard of PET oncologic imaging. However, there has been no report on [C-11] choline PET used for detection of colorectal cancer, which is one of major targets of oncologic FDG-PET. We initiated the research to investigate the detectability of [C-11] choline PET for various tumors including colorectal cancer. This is the first report of a patient who underwent surgical resection for advanced colon cancer depicted by [C-11] choline positron emission tomography/computed tomography.

Key words: radiology-PET – diagnostic radiology – GI-colorectum-basic

INTRODUCTION

[C-11] choline positron emission tomography ([C-11] choline PET) has been expected as a new PET modality and reported to be useful for the detection of various tumors, such as brain tumor, lung cancer, esophageal cancer, prostate cancer, gynecological cancers, and bone and soft tissue sarcomas (1–6). We started the research in our institution on September 1, 2005 to clarify not only the detectability of [C-11] choline PET for various tumors but the mechanism of choline accumulation to cancer cells, which is approved by the Institutional Review Board. Here we report a successful detection of an advanced colon cancer by [C-11] choline PET, which seems to be the first case, and discuss the possibility of application of [C-11] choline PET to colorectal cancer.

CASE REPORT

A 50-year-old woman presented with melena and abdominal discomfort. The colonoscopy showed the elevated lesion in the sigmoid colon (Fig. 1). From endoscopic findings this tumor was diagnosed as type 1 advanced colon cancer with invasion into the subserosa. Pathologic diagnosis by specimen of biopsy was well-differentiated adenocarcinoma. The computed tomography scan of the thorax, abdomen and pelvis revealed the thickening in the wall of the sigmoid colon and enlarged uterus suspected of leiomyoma. No specific enlarged lymph nodes and no definite metastases including the liver were detected. A whole body [C-11] choline positron emission tomography/computed tomography (PET/CT) was performed with the written informed consent to participate in this research approved by the Institutional Review Board. Emission scans from the skull to the mid thigh were obtained starting 14 min after intravenous injection of 444MBq of [C-11] choline, which was synthesized with a commercial module essentially using the method described by Hara and Yuasa (7). [C-11] choline PET images showed abnormal prominent uptake in the middle of the abdomen (Fig. 2a and c). The maximal standardized uptake value (SUV) of this uptake was 6.97. This uptake was suspected to correspond to the sigmoid cancer. However, there was another strong accumulation close to this uptake, suspected to be physiological accumulation to the small intestine (Fig. 2c). It was not so easy to differentiate between these uptakes only by PET images. Fused PET/CT images could show clearly that one prominent accumulation corresponded to the thickening in the wall of sigmoid colon in CT images (Fig. 2d). Low abnormal uptake was observed in the pelvic space, which corresponded to myoma uteri. There was no other abnormal accumulation in
the whole body (Fig. 2a). The patient underwent surgical resection of sigmoid colon and simple hysterectomy. Pathology revealed well-differentiated adenocarcinoma invading the subserosa with two metastatic lymph nodes in N1 group (2/30), which was stage IIIa according to TNM classification (8). These two metastatic lymph nodes were less than 10 mm in diameter and diagnosed as normal lymph nodes on CT images. Lymph node metastases were not detected by [C-11] choline PET. Pathology of the uterus revealed multiple leiomyomas. The patient received adjuvant chemotherapy with 5-FU and leucovorin, and was discharged 13 days after surgery.

**DISCUSSION**

[C-11] choline has been considered as a new PET radiopharmaceutical for tumor detection since Hara et al. reported the usefulness of [C-11] choline PET for detection of brain tumor in 1997 (1). Choline is one of the components of phosphatidylcholine, an essential element of phospholipids in the cell membrane. Malignant tumors usually exhibit a high proliferation of cells and thus are associated with increased metabolism of cell membrane components. This biochemical background will lead to an increased uptake of choline to the cancer cells (9,10). Moreover, it is assumed that, whether tumor cells are in hypoxia or in normoxia, the rate of [C-11] choline uptake in tumors is an indicator of the tumor proliferation rate, whereas in [F-18] fluoro-deoxyglucose (FDG), tumor hypoxia is closely associated with tumor uptake (11). In this view point, [C-11] choline PET might detect malignancies at an earlier stage than FDG-PET, which has spread worldwide as a gold standard of PET oncologic imaging, although further investigation is still needed. Compared with FDG-PET, [C-11] choline PET has the advantage of providing a clear image at an earlier period (5). In FDG-PET, patients have to wait for 60 min or longer after tracer injection for tumor activity to reach the peak count. With [C-11] choline, however, blood clearance is rapid and tumor activity reaches a maximum at 3–5 min after injection. The initial intense uptake remains at a nearly constant level afterwards, thus enabling the high activity ratio to remain for more than 30 min, compared with the background. Another advantage of [C-11] choline PET is the lower exposure dose, which is estimated at approximately 2.5 mSv/370 MBq in contrast with 7 mSv/370 MBq for FDG-PET (12).

[C-11] choline PET has been reported to be useful for the detection of various malignant tumors such as lung, esophageal and gynecological cancers, and bone and soft sarcomas, as well as FDG-PET (1–6). Furthermore, [C-11] choline PET is reported to be superior to FDG-PET in the detection of brain tumor and prostate cancer (1,4). Ramirez de Molina et al. reported that choline kinase, which catalyzes the phosphorylation of choline, is upregulated in lung, prostate and colorectal cancers (13). Therefore, [C-11] choline is speculated to also detect colorectal cancer, which is one of the major targets of FDG-PET. However, there has been no report on [C-11] choline PET for detection of colorectal cancer. This is because it is generally accepted that [C-11] choline often accumulates in the small intestine and/or colon mucosa, in which cell turnover is very rapid. As a consequence, the various degrees of physiological uptake obscure accumulation to the tumor, which is similarly observed in FDG-PET (5). Hara reported that rectal cancer was visualized with [C-11] choline PET (14). In our case, abnormal [C-11] choline deposit to the sigmoid colon could be detected, although there was physiological accumulation to the small intestine near the cancerous lesion. There was no other significant accumulation to the colon. In our experience, physiological colon uptake of [C-11] choline tends to be lower than accumulation in the small intestine, whereas physiological colon uptake of FDG is often so much higher than small intestine uptake that the cancerous lesion cannot be depicted. That might be an advantage of [C-11] choline PET in colorectal cancer. It might be due to the considerably rapid turnover of epithelial cells in the small intestine, but the precise reason is unknown, prompting further investigation. It is sometimes confusing whether abdominal uptake is corresponding to the small intestine or the colon on [C-11] choline PET images as well as on FDG-PET images. In such cases, fused PET/CT images give great assistance in diagnosing correctly the location of abnormal uptake. Besides the detection of the primary site, staging is another important role of oncologic PET as an initial examination. There are some reports on [C-11] choline PET as a staging procedure for prostate cancer and bone and soft tissue sarcomas (15,16). In our case, lymph node metastases could not be detected by [C-11] choline PET. This was considered to be due to the
size of the lymph nodes (less than 10 mm in diameter). Hepatic metastasis, which is frequent in colon cancer, might be hardly depicted by [C-11] choline PET because [C-11] choline is observed physiologically in the liver. However, [C-11] choline PET might be useful for detecting other metastases of colorectal cancer such as brain metastasis, pulmonary metastasis and bone metastasis with low background uptake.

Figure 2. (a) MIP image of [C-11] choline positron emission tomography. Abnormal uptake of [C-11] choline is observed in the middle of the abdomen (arrow). There is no significant physiological uptake in the colon. (b–d) Coronal computed tomography (b), coronal positron emission tomography (c), coronal co-registered positron emission tomography/computed tomography hybrid image (d). Thickening in the wall of the sigmoid colon is observed in the computed tomography (b, arrow). Abnormal uptake of [C-11] choline is observed in the sigmoid colon corresponding to the wall thickening (c, d, arrow). Differentiation between physiological uptake in the small intestine (c, d, arrow head) and tumor uptake can be made by fused PET/CT images. PET, positron emission tomography; CT, computed tomography.
In summary, here we described a case of advanced colon cancer. A whole body [C-11] choline PET/CT permitted detection of the primary site. However, further studies must be performed on staging, diagnosis for recurrence and evaluation for effect of treatment to confirm the usefulness of [C-11] choline PET for colorectal cancer.

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Conflict of interest statement

None declared.

References