Molecular imaging of pancreatic and rectal cancer: on a path towards optimized detection and response prediction

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[^{18}F]FDG PET/CT in Treatment Response Evaluation: Colorectal Cancer

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INTRODUCTION

With an incidence of 1.8 million and nearly 900 thousand deaths in 2018, colorectal cancer has the third highest cancer incidence, and ranks second amongst common causes of cancer death worldwide[1]. As (neo)adjuvant treatment regimens have been adopted into treatment guidelines for both colon and rectal cancer (neoadjuvant short course radiotherapy and long course chemoradiotherapy for rectal cancer, adjuvant chemotherapy for colon cancer), treatment response monitoring has become of evident importance.

Currently, response monitoring is performed using computed tomography (CT) imaging combined with colonoscopy and magnetic resonance (MR) and digital rectal examination in rectal cancer patients. Up to now, the use of positron emission tomography (PET) has not been adopted into colorectal guidelines for response monitoring purposes yet.

[^{18}F]Fluorodeoxyglucose (FDG) PET has the potential to provide metabolic information on tumor cells as indicated by the increased uptake and metabolism of glucose. This provides additional information compared to conventional CT or MR imaging alone. While hybrid PET/CT is a common and widely available technique, developments towards optimizing combined PET/MR scanners are still ongoing but show great promise.

In addition to the combination of PET with CT and MR, much progress is also being made in optimizing PET scanner hardware and software. Most recently, the introduction of the digital PET scanner shows promise to further increase the diagnostic abilities of PET. Previous research and concurrent clinical experience have reported additional value of the use of FDG PET in initial staging of recurrent colorectal cancer and metastases, localizing recurrent disease in patients with unexplained elevation of serum CEA and in the assessment of residual cancerous masses after treatment. However, the use of FDG PET for response monitoring of colorectal cancer is still cumbersome. As this technique provides metabolic data, FDG PET can detect intra-tumoral changes preceding anatomical alterations. The technique shows promise in monitoring, but also in predicting response to given therapy, thereby creating options to establish personalized patient treatment. As PET can not only provide qualitative data, but also quantitative data on multiple lesions simultaneously, monitoring lesions can be performed quantitatively over time.

As (neo)adjuvant therapies thrive and become adopted into standard care, the need for accurate response monitoring increases. This is clearly demonstrated by a subgroup of locally advanced rectal cancer patients, who receive neoadjuvant chemoradiation. A proportion of these patients show a complete remission of tumor and/or pathological lymph nodes after treatment. By accurately selecting these patients, surgery can be omitted, and its associated morbidity and mortality avoided. Current imaging modalities including endoscopy and MR imaging provide reasonable evaluation of residual tumor and/or lymph nodes. However, not all patients with a complete response can be detected. In addition, early detection of non-responders could prevent futile treatment (and its associated side effects) and unnecessary postponing of inevitable surgical resection.

This chapter regarding response monitoring of colorectal cancer using FDG PET/CT, illustrates potential clinical examples in which FDG PET/CT might complement conventional diagnostic imaging modalities in time to come. Further research is however warranted to define the exact situations in which FDG PET/CT can be of additional value. The following clinical cases include response monitoring during neoadjuvant chemoradiation, local treatment of liver metastases, neoadjuvant treatment of recurrent rectal cancer and palliative systemic treatment of hepatic and extrahepatic disease.

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CLINICAL CASE 1 - COLORECTAL LIVER METASTASIS

Clinical details: A 55-year-old male with a history of a sigmoid resection for a pT2N0M0 sigmoid carcinoma and metastasectomy for a metachronous liver lesion in segment Iva three years later. Three months after the metastasectomy, radiofrequency ablation (RFA) was performed on a second lesion in segment III. Now, six years after resection of the primary tumor, serum CEA is elevated, and no metastases were detected prospectively on CT imaging of the chest and abdomen.

Scan findings: A solitary FDG avid lesion is detected in the caudate liver lobe. Also, a photopenic area from the metastasectomy is observed in segment IVa. No evidence of disease recurrence is seen at the anastomosis site.

Interpretation: Suspected solitary liver metastasis in the caudate liver lobe.

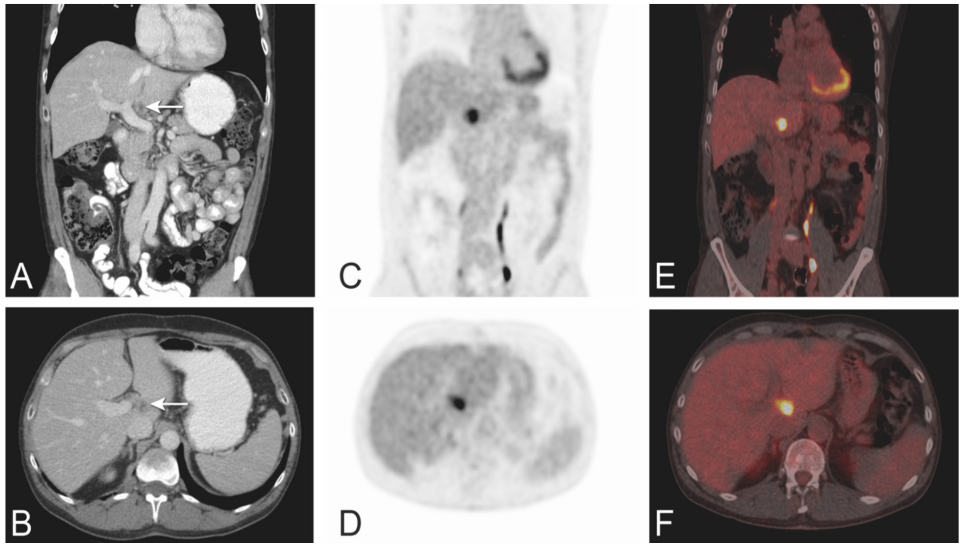

FIGURE 1. Solitary liver metastasis. Coronal (A, C, E) and axial (B, D, F) images of a solitary liver metastasis in the caudate liver lobe (segment I). Representative images of CT (A, B), PET (C, D) and PET/CT (E, F).

Teaching points:

- FDG PET/CT has a higher sensitivity for detecting colorectal liver metastases compared to contrast enhanced CT[2].
- FDG PET/CT can be helpful to localize recurrent disease in case of elevated CEA and undetectable disease on CT[3].

CLINICAL CASE 2 - COLORECTAL LIVER METASTASIS

Clinical details: A 55-year-old male with a history of a coecum carcinoma for which a right hemicolectomy was performed, developed multiple metachronous liver metastases six years later. Left hemi hepatectomy and multiple metastasectomies were performed. One year later, RFA was performed on a recurrent liver metastasis. One year after the RFA, thus 8 years after primary diagnosis, at least 3 suspicious new liver lesions were found on FDG PET/CT (Fig. 2A-B) and deemed unresectable. Systemic treatment consisting of capecitabine, oxaliplatin and bevacizumab was initiated.

Scan findings: Complete remission of the liver metastases (Fig. 2C-D). No evidence of other (extra) hepatic metastases.

Interpretation: Complete response of liver metastasis after therapy.

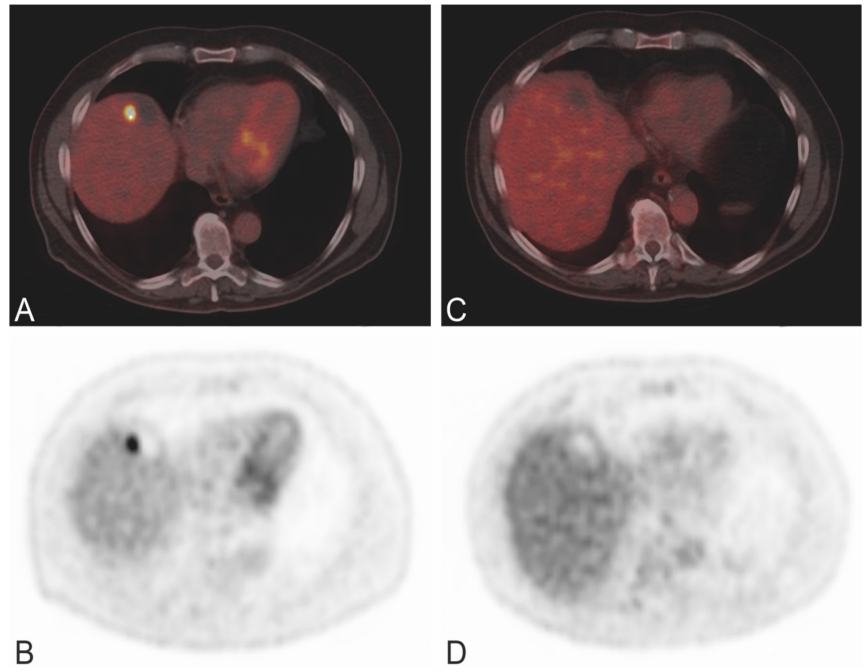

FIGURE 2. Response monitoring liver metastasis. Images of PET/CT (A, C) and PET (B, D) before (A, B) and after six cycles of therapy (C, D).

Teaching point:

- FDG PET/CT can reliably monitor response of liver metastases to systemic treatment.

CLINICAL CASE 3 - SEQUEL TO CASE 2

Clinical details: Four years after therapy, recurrent liver metastases were detected. Capecitabine monotherapy was restarted, and FDG PET/CT was used for response monitoring.

Scan findings: A persistent strong FDG avid metastasis is seen in segment 6/7 (Fig. 3A, E, I), SUV_{max} remains unchanged, however metabolic volume increases. FDG PET/CT shows no changes in the highly active lesion in segment 8 (Fig. 3 C, G, K).

Interpretation: Stable disease in liver segment 8, slight increase in metabolic volume in segment 6/7. As previous experience in this patient showed stabilizing and eventually decreasing disease with continuous capecitabine treatment, treatment is continued, and evaluation is scheduled after 3 cycles.

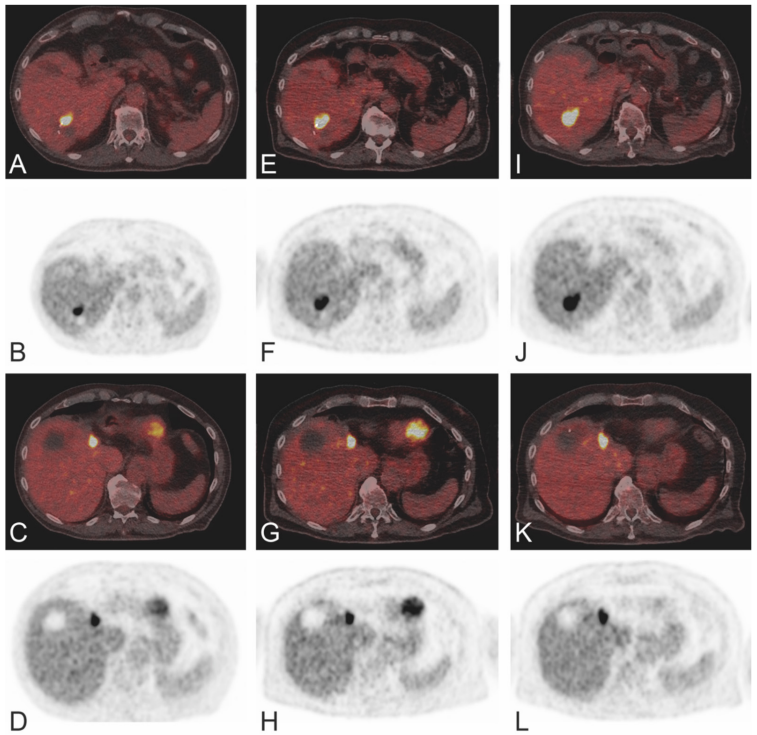

FIGURE 3. Response monitoring liver metastases. PET/CT (A, C, E, G, I, K) and PET (B, D, F, H, J, L) images before (A-D), after 3 cycles (E-H) and after 6 cycles (I-L) of capecitabine treatment.

Teaching point:

- Serial SUV_{max} measurements can monitor therapy response of liver metastases to chemotherapy.

CLINICAL CASE 4 - RESPONSE MONITORING OF LIVER METASTASES

Clinical details: A 74-year-old female with colon cancer and multiple synchronous liver metastases was treated with combination therapy consisting of capecitabine and bevacizumab. Treatment was terminated after 2 cycles due to liver failure, likely due to progressive liver metastases. Four weeks after termination of the treatment, the patient passed away.

The patients participated in a clinical trial, during which PET/CT imaging was performed. The research objective was to evaluate the predictive value of pretreatment PET/CT measurements and early changes one week after the start of therapy [4].

Scan findings: Mean SUV_{max} (of 5 lesions) was 15 before treatment, and 13 after 1 week of treatment. Total lesion glycolysis (TLG) in the same five lesions increased slightly from 3450 to 3565.

Interpretation: Progressive disease is observed as metabolic volume has increased.

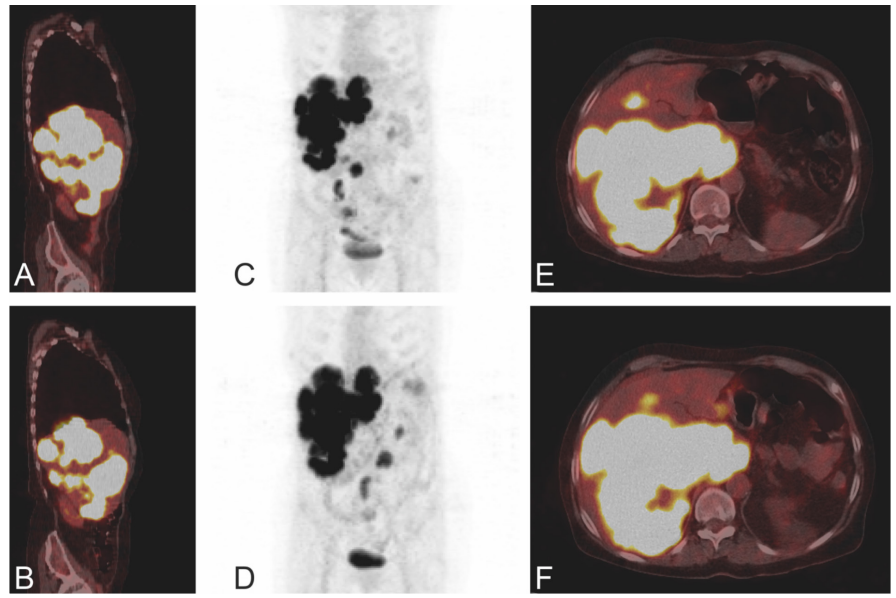

FIGURE 4. Response monitoring of liver metastases. Images of PET/CT (A, B, E, F) and the maximum intensity projection (C, D) before (A, C, E) and after (B, D, F) treatment.

Teaching points:

- FDG PET can identify patients not responding to therapy, thereby aiding in the decision to terminate treatment when no benefit is expected. Early response monitoring is challenging using CT, and only useful 8 weeks after start of treatment.

CLINICAL CASE 5 - RESPONSE MONITORING OF LIVER METASTASES

Clinical details: A 56-year-old male with colon cancer and synchronous liver metastases is treated with systemic therapy, a combination of capecitabine, oxaliplatin (CAPOX) and bevacizumab.

Scan findings: Mean SUV_{max} (of five lesions) was 7.0 before treatment, 7.0 one week into treatment and 6.8 after three cycles. TLG decreased from 320 before treatment to 230 after one week, and further to 100 after three cycles.

Interpretation: Partial response after three cycles of anti-tumor treatment.

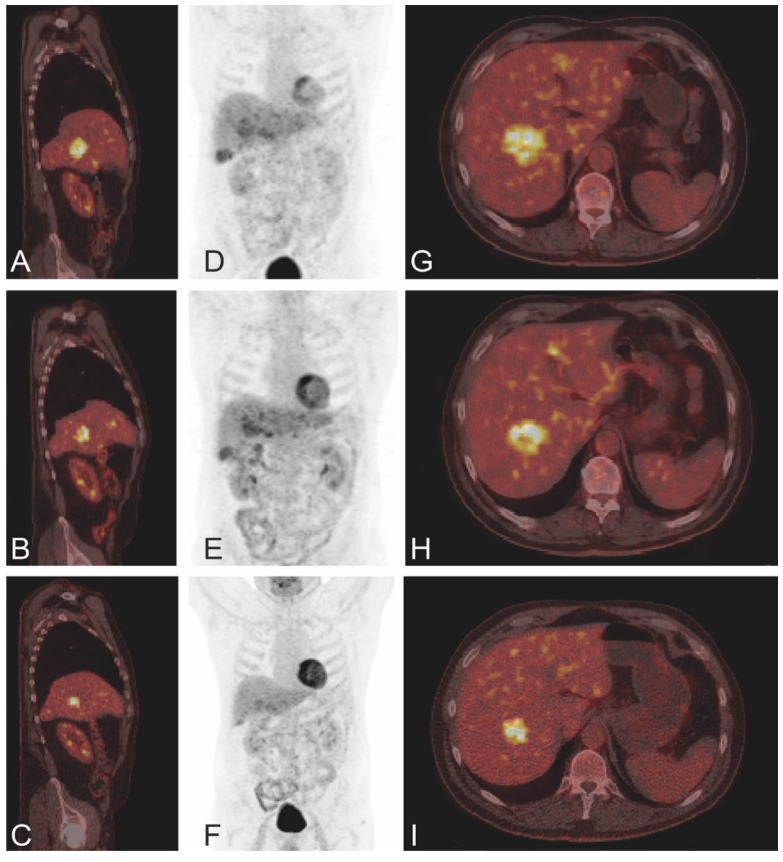

FIGURE 5. Response monitoring of liver metastases. PET/CT (A, B, C, G, H, I) and maximum intensity images (MIP)(D, E, F) before (A, D, G), after one week of therapy (B, E, H) and after 3 cycles (C, F, I).

Teaching points:

- Serial FDG PET/CT measurements can monitor therapy response of liver metastases to combination therapy (chemotherapy and anti-angiogenic treatment).

CLINICAL CASE 6 - RESPONSE MONITORING OF LIVER AND OTHER METASTASES

Clinical details: A 65-year-old male with colon cancer and synchronous liver and lung metastases was treated with neoadjuvant therapy, a combination of CAPOX and bevacizumab.

Scan findings: Mean SUV_{max} of the three liver lesions was 8.4 before treatment, 7.4 after one week and 4.2 after three cycles. TLG of the liver lesions was 950 before treatment, 680 after one week and 95 after three cycles.

Interpretation: Partial response to chemotherapy of the primary tumor, liver metastases and lung metastases.

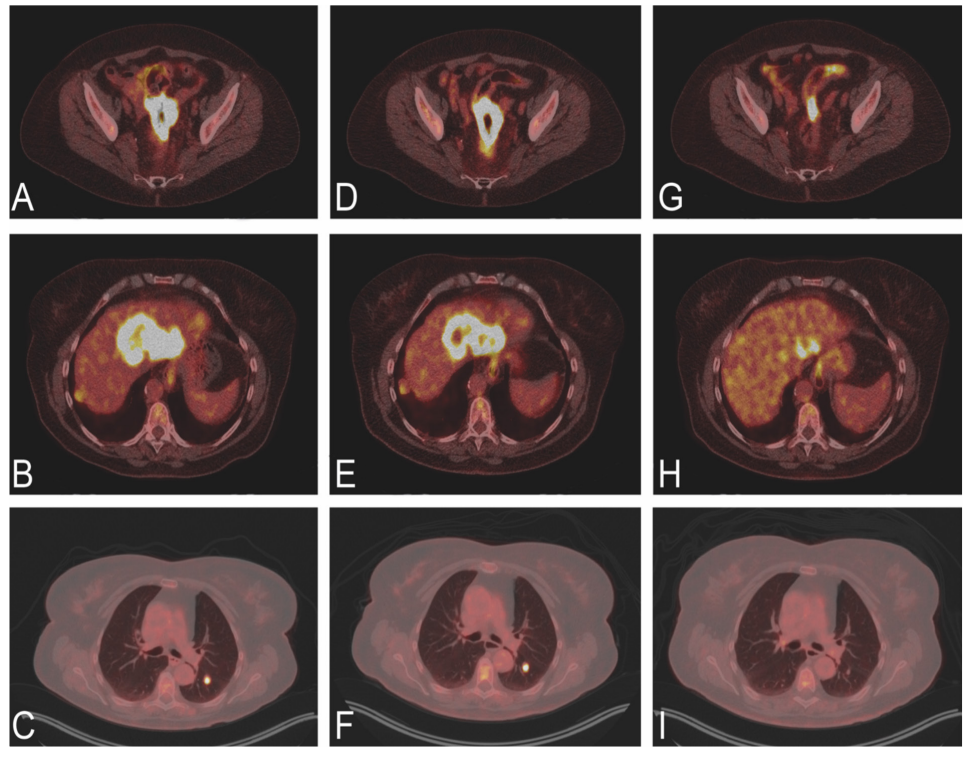

FIGURE 6. Response monitoring of liver metastases. PET/CT images before treatment (A-C), one week into treatment (D-F) and after three cycles (G-I) of respectively the primary tumor, liver metastases and lung metastases.

Teaching points:

- Early response monitoring is feasible using FDG PET/CT.

CLINICAL CASE 7 - RESPONSE MONITORING OF LIVER METASTASES

Clinical details: A 75-year-old male with colon cancer and synchronous liver metastases was treated with a combination of neoadjuvant CAPOX and bevacizumab to increase the chance of resectability of the liver metastases.

Scan findings: As the first three scans were part of research, SUV_{max} and TLG analysis was performed. SUV_{max} was 11 before treatment, 9 after one week of treatment and 7 after three cycles (nine weeks). Total lesion glycolysis decreased from 1200 before start of treatment to 500 after one week of therapy and decreased further to 220 after three cycles.

Interpretation: Partial response of liver lesions after three cycles, as well as after six cycles. Hereafter, the patient underwent metastasectomy. After this, no evidence of residual or recurrent disease was observed during 24 months of follow-up.

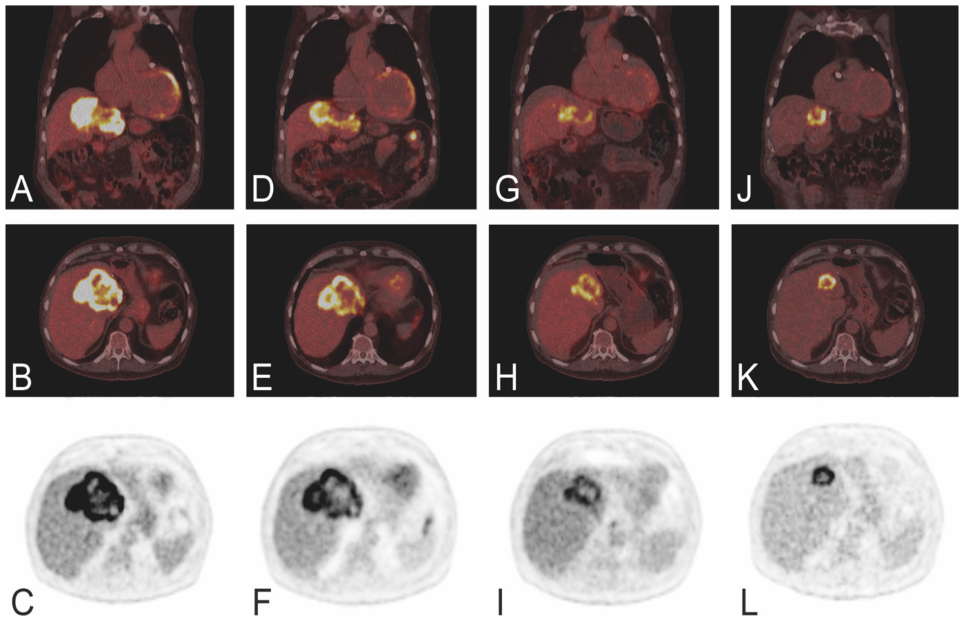

FIGURE 7. Response monitoring of liver metastases. PET/CT (A, B, D, E, G, H, J, K) and PET (C, F, I, L), before treatment (A-C), one week into treatment (D-F), after three cycles (G-I) and after six cycles (J-L).

Teaching point:

- Current response monitoring is performed using the RECIST criteria by evaluating the size of lesions 8-9 weeks after treatment. Metabolic response to anti-tumor treatment can be visualized earlier.

CLINICAL CASE 8 - RESIDUAL DISEASE AFTER LIVER METASTASECTOMY?

Clinical details: A 60-year-old male with rectal cancer and a solitary metachronous liver metastasis for which neoadjuvant short-course radiotherapy was administered and resection was performed. No previous systemic treatment has been given. PET/CT is performed before and four days after surgical metastasectomy.

Scan findings: SUV_{max} prior to resection is 7. After resection, slight diffuse uptake is seen along the edge of the resection cavity.

Interpretation: No evidence of residual disease. Postoperative changes are appreciated at the edge of the resection cavity.

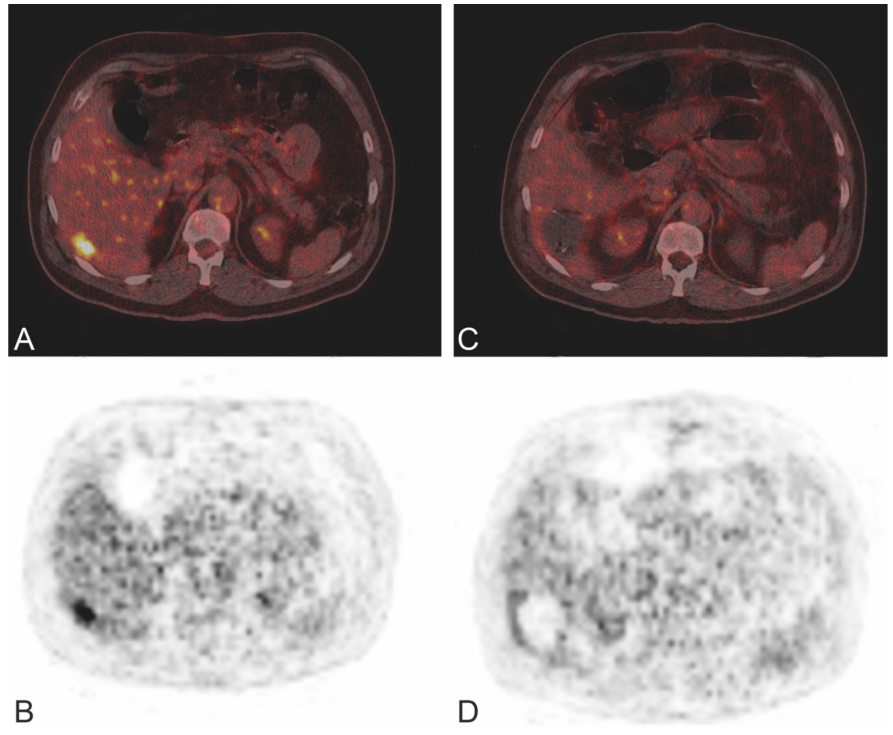

FIGURE 8. Evaluation after liver metastasectomy. PET/CT (A, C) and PET (B, D) images before (A-B) and 4 days after metastasectomy (C-D).

Teaching point:

- Physiologic mild diffuse uptake along the edge of metastasectomy can be seen in the first days to weeks after metastasectomy.

CLINICAL CASE 9 - PALLIATIVE TREATMENT OF LIVER METASTASES OF RECTAL CANCER

Clinical details: A 63-year-old male with rectal cancer in whom two synchronous liver metastases were detected. The patient was treated with palliative chemotherapy consisting of tegafur and uracil, as no curative options were available. CT imaging showed stable disease after 3 cycles according to RECIST.

Scan findings: Mean SUV_{max} of the two liver lesions was 8.0 before treatment, 9.0 after one week (+13%) and 9.4 after three cycles of treatment (+18%). Total lesion glycolysis was 34 before treatment, 46 after one week (+35%) and 40 (+18%) after three cycles.
Interpretation: Stable disease on PET/CT (PERCIST).

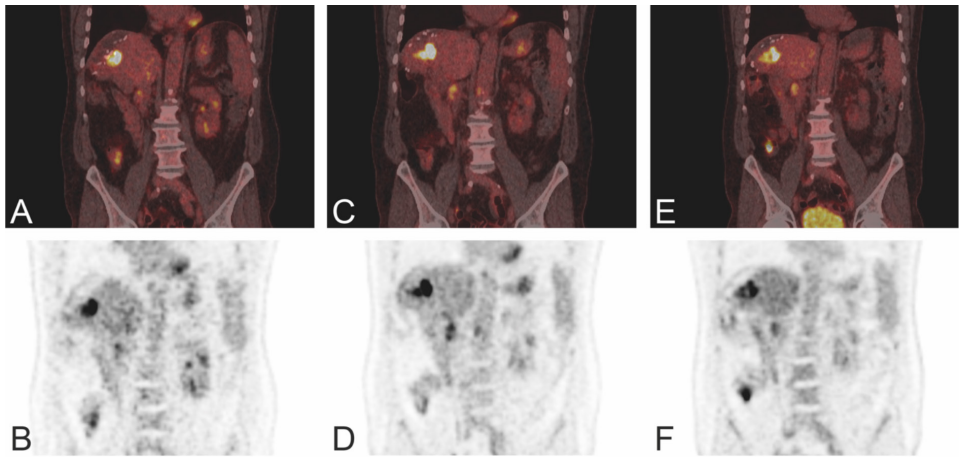

FIGURE 9. Response monitoring palliative rectal cancer. Representative PET/CT (A, C, E) and PET (B, D, F) images before treatment (A, B), one week into treatment (C, D) and after 3 cycles of treatment are depicted (E, F).

Teaching point:

- Fractional changes in tumor glucose metabolism on FDG PET/CT can stratify patients into groups with different survival probabilities[5].

CLINICAL CASE 10 - RECURRENT DISEASE AFTER LIVER MICROWAVE ABLATION (MWA)

Clinical details: A 75-year-old male with a history of pT3N0M0 sigmoid cancer which was laparoscopically resected. Four years later, CEA was elevated, and a liver metastasis was detected in segment VIII on CT, which was treated with MWA (5 min, 100W). Routine follow up CT imaging 3 months after MWA showed no evidence of residual or recurrent disease. Five months later, CEA is again elevated and a lesion suspicious for recurrent metastasis was observed on FDG PET/CT (Fig. 10D). Subsequent MR imaging (one week later) confirmed a solitary recurrent liver metastasis (Fig. 10C).

Scan findings: A high metabolically active focus is located mediodorsal of the MWA area, cranial in segment VIII. The focus corresponds to the hypodense lesion as seen on CT and MRI.

Interpretation: Images suspicious for local recurrence after MWA of a liver metastasis in segment eight.

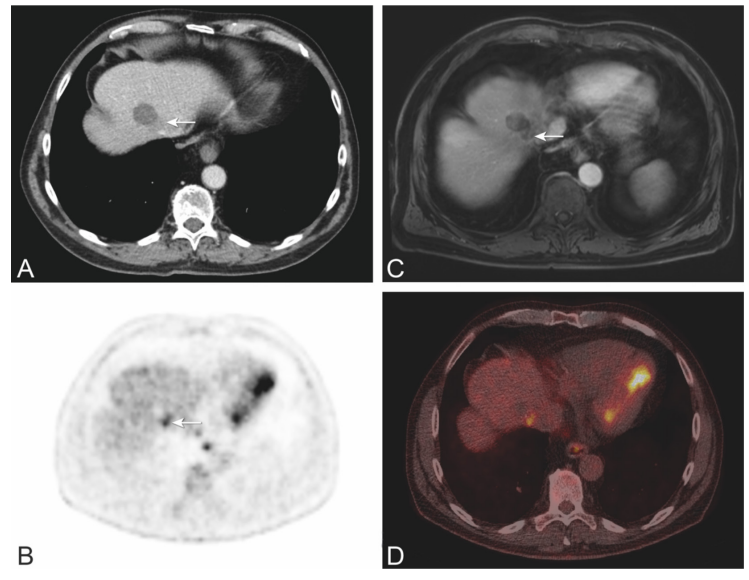

FIGURE 10. Recurrent disease after liver MWA. Images of contrast enhanced CT (A), PET (B), contrast enhanced MRI (C) and PET/CT (D) are depicted.

Teaching points:

- FDG PET/CT is accurate in detecting residual or recurrent disease immediately after local ablative therapy[6].
- Focal and multifocal uptake is suspicious for recurrent disease already in the first months after local therapy.

CLINICAL CASE 11 - RECURRENT DISEASE AFTER LIVER RFA

Clinical details: A 75-year-old male with cT3N2M1 sigmoid carcinoma with multiple synchronous liver metastases in segment VII and VIII. Induction combination chemotherapy consisting of folinic acid, fluorouracil and oxaliplatin (FOLFOX) was given. Following systemic therapy, the liver lesions decreased in size but were still present. Both the primary tumor and liver metastases were resected or ablated using radiofrequency. Eighteen months later, serum CEA was rising, however, recurrent disease could not be localized on CT of the chest and abdomen.

Scan findings: Status after sigmoid resection, segment resection of segment 8 and RFA in segment 8/5. Focal FDG avidity is seen along the medial edge of the RFA area. No evidence of other metastases.

Interpretation: The FDG avidity in the liver lesion is suspect for a recurrent liver metastasis along the edge of the previous RFA cavity.

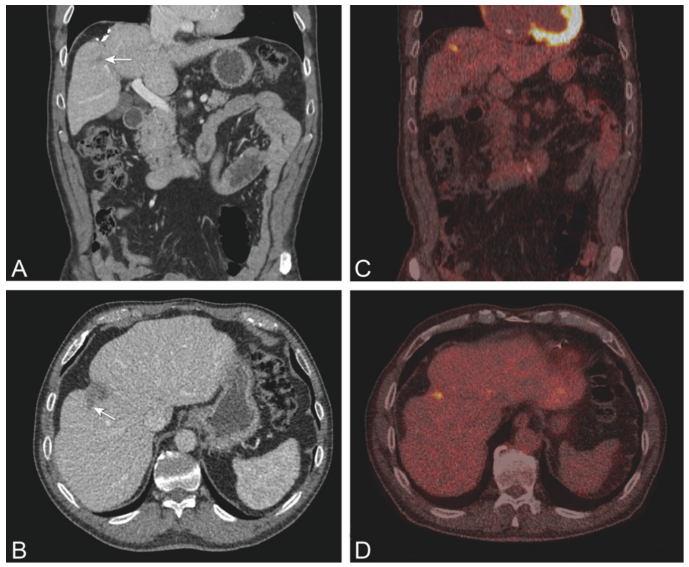

FIGURE 11. Recurrent disease after liver RFA. Images of CT (A, B) and PET/CT (C, D).

Teaching points:

- FDG PET/CT is more accurate during surveillance after RFA compared to contrast enhanced CT and MRI[7,8].
- Response evaluation after RFA can be performed by FDG PET/CT, as responding lesions become photopenic immediately following RFA[9].
- Focal and multifocal uptake is suspicious for recurrent disease following local therapy.

CLINICAL CASE 12 - RECURRENT DISEASE AFTER LIVER RFA

Clinical details: A 60-year-old male with pT1N1M1 colon carcinoma with a synchronous liver metastasis. The colon carcinoma was resected, after which the solitary liver metastasis in segment seven was ablated using radiofrequency (RFA). Eight months later, a recurrent liver lesion is seen along the ablated site in segment VII on FDG PET/CT (Fig. 12D). Subsequent MR imaging confirmed a solitary liver metastasis in segment VII.

Scan findings: High FDG avidity is seen cranially in segment 7/8, corresponding to the lesion as seen on MRI located dorsolateral on the right side adjacent to the RFA cavity. No other FDG accumulation is observed in the liver parenchyma.

Interpretation: FDG uptake highly suspicious for local recurrent disease dorsolateral along the RFA cavity, corresponding to the lesion observed on MRI. No other metastases are detected.

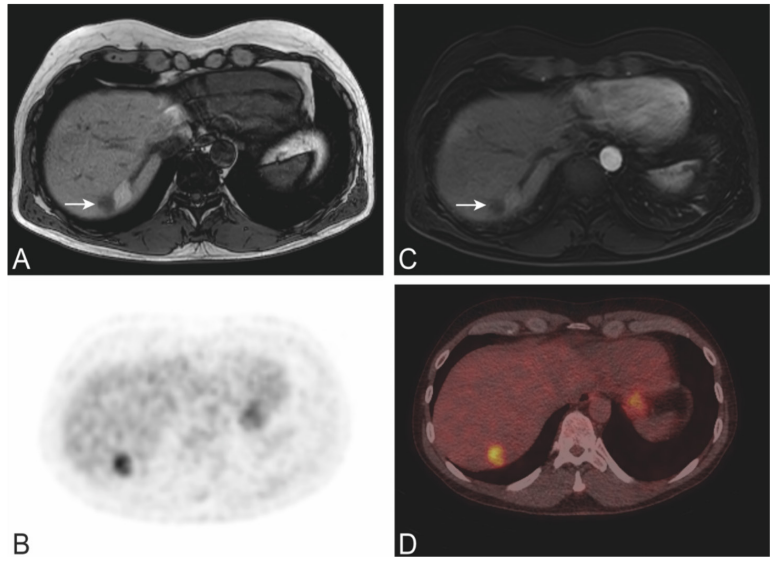

FIGURE 12. Recurrent disease after liver RFA. Images of T1 weighted MRI before contrast (A), PET (B), contrast enhanced MRI (C) and PET/CT (D).

Teaching points:

- FDG PET/CT is more accurate during surveillance after RFA compared to contrast enhanced CT or MRI[7,8].
- FDG PET shows promise in identifying very early response after local ablative treatment (within 24 hours post ablation)[9].
- Focal and multifocal uptake is suspicious for recurrent disease following local therapy.

CLINICAL CASE 13 - PULMONARY METASTASES

Clinical details: An 80-year-old woman underwent laparoscopic sigmoid resection seven years ago for a pT3N0M0 sigmoid carcinoma. Three years after resection, local recurrence and multiple liver and lung metastases were detected and treated in the following years. Three lung metastases were treated with stereotactic radiotherapy. Five months later, CT imaging reveals progression of the known apical consolidation after radiotherapy in the left lower lobe and progression of a lung nodule in the right upper lobe. FDG PET/CT also shows moderate uptake in the progressive area, however uptake may be due to post radiation inflammation. Now, 18 months after stereotactic radiotherapy (STRT), another FDG PET/CT is performed.

Scan findings: Diffuse mild FDG uptake is observed in the area in the right upper lobe after STRT. However, avid FDG uptake is seen in three lung nodules 18 months after STRT. Two of these nodules are in the right upper lobe (one in and the other located dorsally from the radiation area, Fig. 13C-D), and one nodule in the left lower lobe.

Interpretation: Status after stereotactic radiotherapy of two pulmonary metastases. However, three new lung metastases are seen 18 months after STRT. Two in the right lung, 1 in the left. No evidence of other metastases or local recurrence.

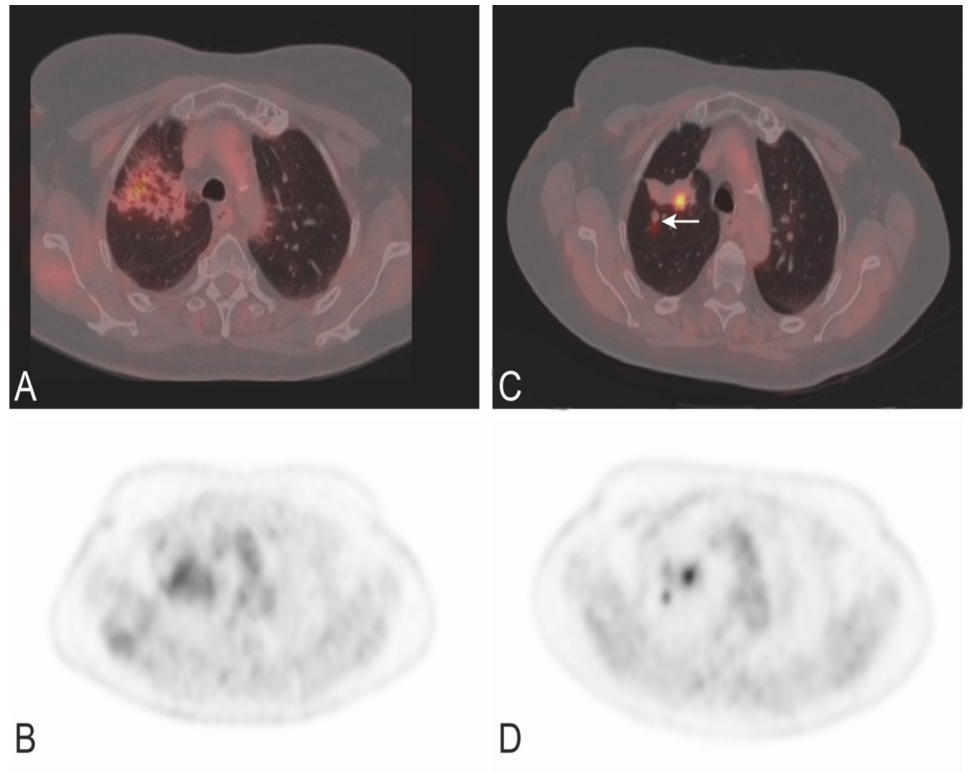

FIGURE 13. Lung metastasis. Images of PET/CT (A, C) and PET (B, D) 11 months after STRT (A, B) compared to 18 months after STRT (C, D). Note a location mismatch between PET and CT imaging is visible in the smaller nodule, as indicated by the arrow due to differences in respiration.

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Teaching points:

- As few patients with pulmonary oligometastases from colorectal origin are eligible for local therapy, early detection is crucial.
- The sensitivity and specificity of FDG PET/CT for detecting pulmonary metastases from colorectal cancer are respectively 57.1 and 99.1%[10]. This is mainly due to the small size and partial volume effect.
- Although CT has higher sensitivity compared to FDG PET/CT in detecting lung nodules (90 vs. 57-76%), FDG PET/CT provides higher specificity (75-99 vs. 50%)[10,11]. However, serial CT imaging probably provides high specificity as well, as is seen in common practice. Such approach, however, is not useful when early specific diagnosis is crucial.

CLINICAL CASE 14 - LYMPH NODE METASTASES

Clinical details: A 65-year-old woman with a history of breast cancer, to whom after resection, adjuvant chemo- and radiotherapy was given. Six years later, the patient presents with cT3N2M0 sigmoid carcinoma for which sigmoid resection was performed, followed by adjuvant chemotherapy (three cycles of capecitabine). Ten months later, two liver metastases from the sigmoid carcinoma (segment VI and VIII) were resected. In the same period, two para-aortal lymph nodes were resected. Now, three years after liver metastasectomy, new enlarged lymph nodes are detected. The patient is treated with three cycles of capecitabine.

Scan findings: As compared to the first scan, no significant change in size and metabolic activity of the left para-aortal and mediastinal lymph node metastasis is measured. Note that the hypermetabolic mediastinal lymph node is not enlarged.

Interpretation: Stable disease of both lymph node metastases is seen after 3 cycles.

Teaching points:

- As treatment decisions depend om presence of hepatic and extrahepatic metastases, FDG PET/CT can aid in providing accurate staging, leading to more effective patient management decisions[12].
- FDG PET/CT can alter staging for assessing extrahepatic disease in up to 20% of patients[12].
- FDG PET/CT can identify additional metastatic lymph nodes that are missed on CT imaging.
- Caution is warranted in SUV quantification of lymph nodes because of the possible partial volume effect.

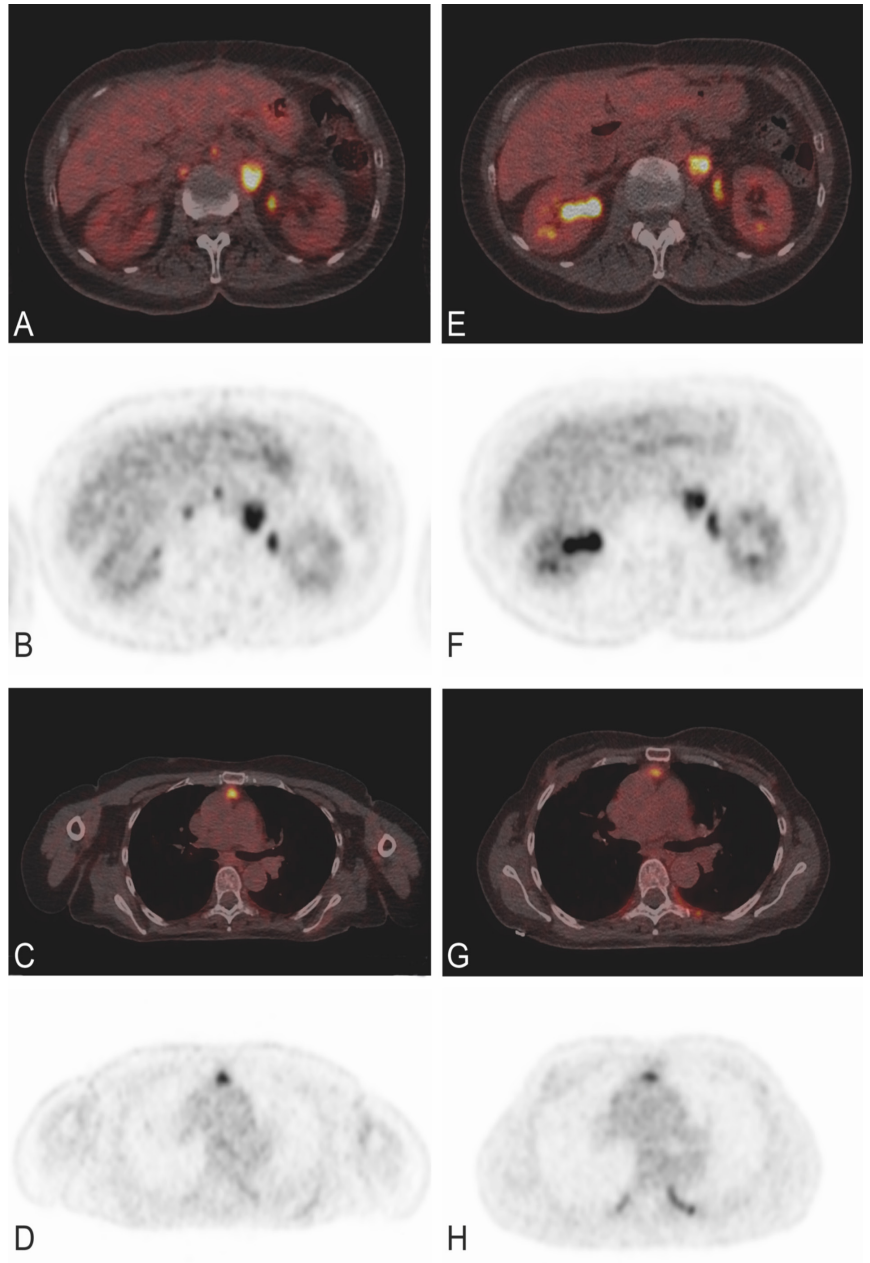

FIGURE 14. Response monitoring lymph node and pulmonary metastases. PET/CT (A, C, E, G) and PET (B, D, F, H) images before (A-D) and after (E-H) three cycles of capecitabine.

CLINICAL CASE 15 - RESPONSE MONITORING TO NEOADJUVANT CHEMORADIOTHERAPY

Clinical details: A 60-year-old male with cT3N2M0 locally advanced rectal carcinoma for which neoadjuvant chemoradiation (25x2 Gy and concurrent capecitabine) was given. After neoadjuvant therapy, abdominoperineal resection was performed. The resection specimen showed ypT1N0 rectal adenocarcinoma on pathological examination. Response monitoring was performed using FDG PET/CT.

Scan findings: FDG accumulation in the primary rectal carcinoma decreased during neoadjuvant therapy. SUV_{max} at staging was 27, decreased to 21 two weeks into treatment and to 8.5 eight weeks after neoadjuvant treatment. No enlarged or avid lymph nodes were visible.

Interpretation: Partial response of the primary tumor.

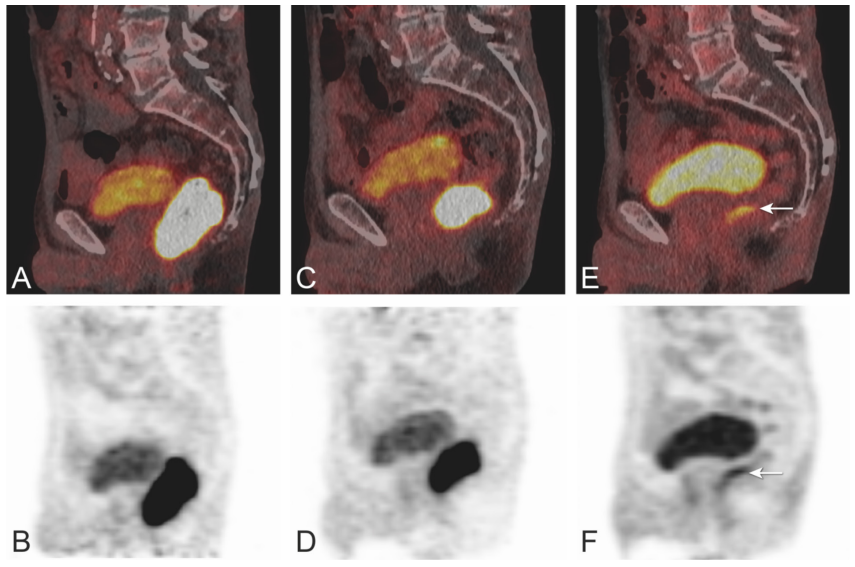

FIGURE 15. Response monitoring locally advanced rectal cancer. Images show PET/CT (A, C, E) and PET (B, D, F) images before (A, B), two weeks into treatment (C, D) and 6-8 weeks after neoadjuvant treatment (E, F).

Teaching points:

- FDG PET/CT can predict (early) tumor response to therapy. However, thresholds derived from large clinical trials are still lacking[13].
- In the future, by monitoring early tumor response, neoadjuvant treatment can be adjusted and/or futile chemo(radio)therapy can be avoided in non-responding patients.

CLINICAL CASE 16 - MONITORING RESPONSE TO NEOADJUVANT CHEMORADIOTHERAPY

Clinical details: A 60-year-old male with cT3N2M0 locally advanced rectal carcinoma for which neoadjuvant chemoradiotherapy (25x2 Gy and concurrent capecitabine) was started, followed by total mesorectal excision (TME) resection. The resection specimen showed ypT3N1 rectal adenocarcinoma. Response monitoring was performed using FDG PET/CT.

Scan findings: SUV_{max} at baseline was 26, it decreased to 12 two weeks into treatment and eight weeks after neoadjuvant treatment SUV_{max} further decreased to five.

Interpretation: A strong metabolic response is observed.

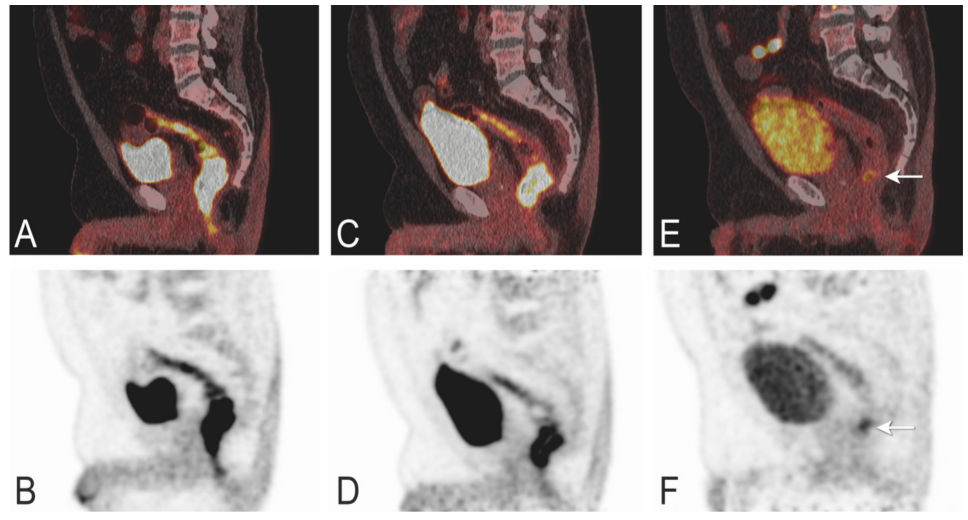

FIGURE 16. Response monitoring rectal cancer. Images show PET/CT (A, C, E) and PET (B, D, F) images before (A, B), two weeks into treatment (C, D) and 6-8 weeks after neoadjuvant treatment (E, F).

Teaching points:

- FDG PET/CT can predict (early) tumor response to therapy. However, thresholds derived from large clinical trials are still lacking[13].
- In the future, by monitoring early tumor response, neoadjuvant treatment can be adjusted and/or futile chemo(radio)therapy can be avoided in non-responding patients.

CLINICAL CASE 17 - RECURRENT COLORECTAL CANCER

Clinical details: A 60-year-old male with cT3N0M0 proximal rectal cancer for which neoadjuvant chemoradiotherapy was given, followed by TME resection. Nine months later, recurrent rectal cancer was diagnosed, and the patient was treated with one cycle CAPOX followed by re-chemoradiation (15x2Gy in combination with capecitabine) and three additional cycles of CAPOX, followed by resection. Two FDG PET scans were performed, one during the first cycle of CAPOX, the second during the last cycle of CAPOX, 2 months later.

	During first cycle	During third cycle
SUV_{max}	11.6	11.2
Metabolic volume	77.3	67.8

Scan findings: No change in the intense FDG accumulation in the dorsal rectal wall above the anastomosis is seen. A large tumor strand is observed right cranially along the mesorectum.

Interpretation: Unchanged recurrent rectal tumor in the presacral area with strand cranial along the mesorectum. No signs of lymph node metastases. Subsequently, pelvic exenteration was performed. Three months after resection, recurrent disease was diagnosed, and palliative chemotherapy was initiated.

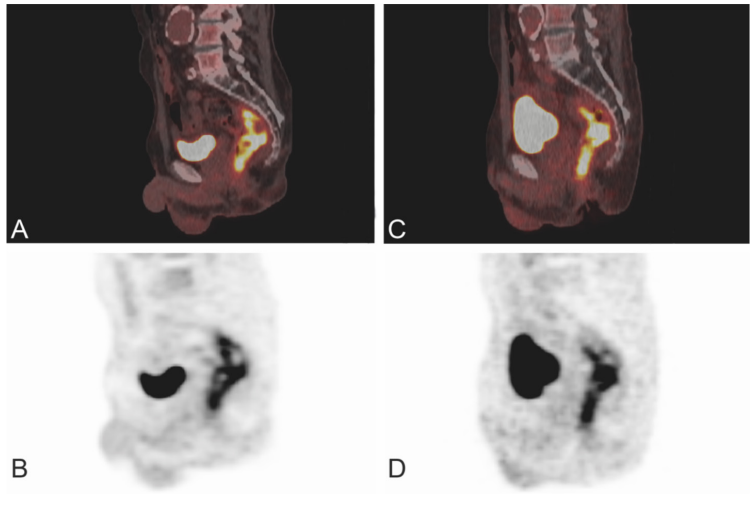

FIGURE 17. Response monitoring recurrent rectal cancer. Representative images of PET/CT (A, C) and PET (B, D) one week into treatment (A, B) and during the third cycle of treatment (C, D).

Teaching point:

- FDG PET/CT might aid in detecting recurrent rectal cancer patients not responding to therapy.

CLINICAL CASE 18 - RECURRENT COLORECTAL CANCER

Clinical details: A 65-year-old male with pT3N2M0 sigmoid tumor who underwent sigmoid resection. The patient received eight cycles of adjuvant CAPOX, oxaliplatin was terminated after the fourth cycle due to toxicity. Two months after the last cycle, serum CEA was elevated.

Scan findings: High FDG uptake is seen at the anastomosis site (Fig. 18E). Also, high uptake is observed in a possible peritoneal metastasis more proximal along the sigmoid (Fig. 18F). High uptake is appreciated in a left parailiacal lymph node (dotted white arrow, Fig. 18A). FDG avid foci are seen in the pararenal fascia (black arrow Fig. 18A) and peritoneum (white arrows Fig. 18A).

Interpretation: Images are suspicious for recurrent disease at the anastomosis site with metastases to the peritoneum, lymph nodes, omentum and right pararenal fascia.

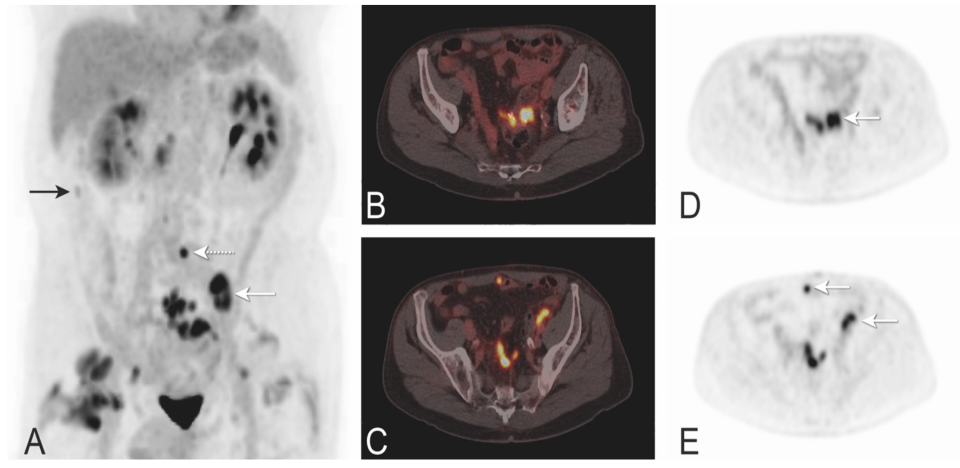

FIGURE 18. Local recurrence sigmoid tumor. Images of the maximum intensity projection (MIP, A), CT (B), PET/CT (C, D) and PET (E, F) are depicted. The recurrent tumor is indicated by the arrow in D, whereas the peritoneal metastases are indicated by the arrows in E.

Teaching points:

- Detection of local recurrence on CT and MRI can be challenging due to altered anatomy after oncologic resection.
- FDG PET/CT has a high sensitivity (84-100%), specificity (80-100%) and accuracy (74-94%) in detecting local recurrence of colorectal cancer[14]. Therefore, PET/CT has been adopted into colorectal guidelines for detection of local recurrence.

CLINICAL CASE 19 - RESPONSE MONITORING OF NEOADJUVANT TREATMENT OF LOCAL RECURRENT RECTAL CANCER

Clinical details: A 70-year-old male with pT3N2M1 rectal carcinoma and a synchronous solitary liver metastasis. The liver metastasis was treated with 3 neoadjuvant courses of CAPOX, after which RFA was performed. Following this, abdominoperineal resection of the primary rectal cancer was performed. Two years after resection, local recurrent disease was detected in a lymph node and was treated with 4 courses of induction chemotherapy (FOLFIRI) followed by chemoradiotherapy (capecitabine in combination with 15 x 2 Gy). FDG PET/CT was performed to monitor response.

Scan findings: Partial metabolic response was visualized on the interim scan after neoadjuvant chemotherapy (2 months later). A complete metabolic response was observed right after neoadjuvant chemoradiotherapy (5 months later).

Interpretation: A complete metabolic response is seen on the last scan, as was confirmed by the resection specimen showing a pathological complete response. Following neoadjuvant treatment, debulking surgery and intraoperative radiotherapy was performed. The resection specimen showed a pathological complete response to neoadjuvant therapy.

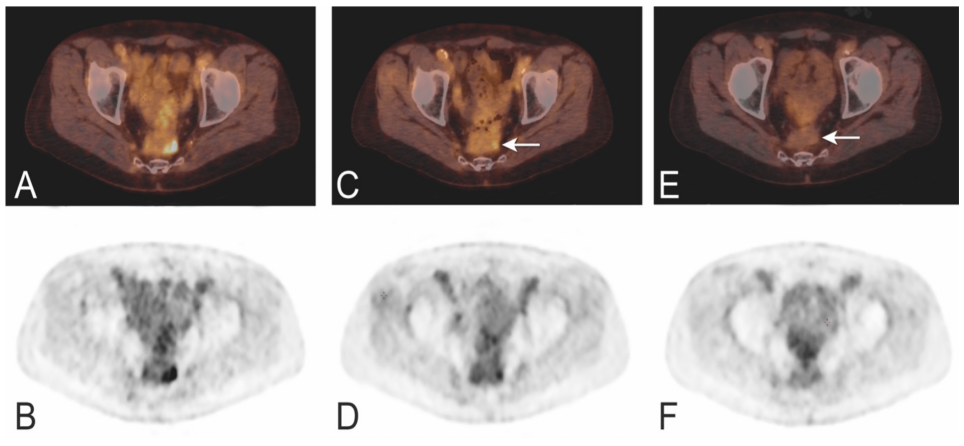

FIGURE 19. Response monitoring neoadjuvant treatment local recurrence.
Representative PET/CT and PET images before treatment (A, B), after neoadjuvant chemotherapy (C, D) and after neoadjuvant chemoradiation (E, F) are depicted.

Teaching points:

- FDG PET/CT can provide additional information on the decision to give consolidation therapy between neoadjuvant therapy and surgery.

CLINICAL CASE 20 - RESPONSE MONITORING OF NEOADJUVANT TREATMENT OF LOCAL RECURRENT RECTAL CANCER

Clinical details: A 60-year-old male with locally advanced rectal carcinoma was treated with neoadjuvant chemoradiotherapy, followed by TME resection. Eighteen months later, local recurrent disease was detected and treated with induction chemotherapy (1 course CAPOX, then switched to 3 courses FOLFIRI due to toxicity) followed by chemoradiotherapy (capecitabine in combination with 15 x 2 Gy). Response monitoring was performed by FDG PET/CT.

Scan findings: No changes in FDG avidity were observed after neoadjuvant chemotherapy or after neoadjuvant chemoradiotherapy.

Interpretation: Stable disease was observed after neoadjuvant chemotherapy (2 months later) and immediately after neoadjuvant chemoradiotherapy (4 months later). Following treatment, surgical resection was planned.

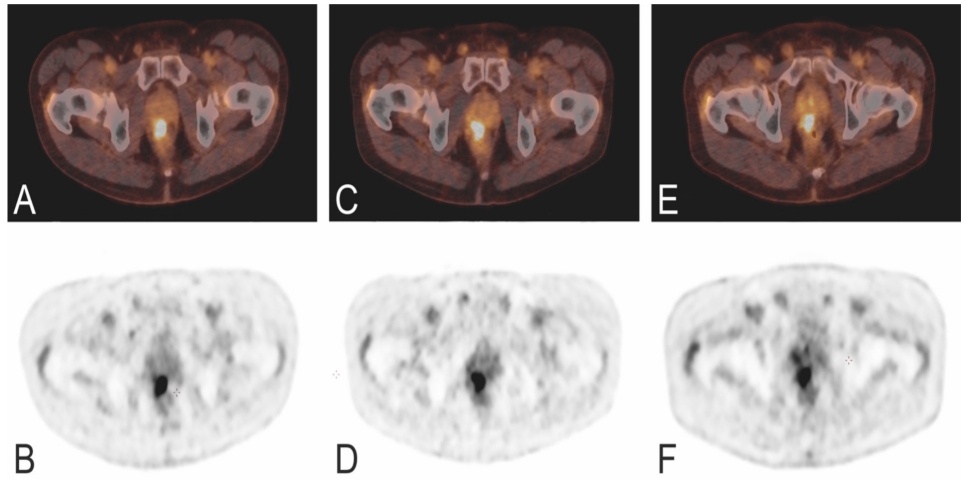

FIGURE 20. Response monitoring neoadjuvant treatment local recurrence.
Representative PET/CT and PET images before treatment (A, B), after neoadjuvant chemotherapy (C, D) and after neoadjuvant chemoradiation (E, F) are depicted.

Teaching point:

- FDG PET/CT can provide additional information on the decision to give consolidation therapy between neoadjuvant therapy and surgery.

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