Original Article

Omental deposits surveillance in gynecological malignancies at first setting follow up: $^{18}$F-FDG PET/CT compared to CT

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A R T I C L E  I N F O

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A B S T R A C T

Objective: The aim of this study was to compare the diagnostic performance of positron emission tomography/computed tomography (PET/CT) scan and CT scan in follow up of proven gynecological malignancies omental deposits in first setting follow up after treatment.

Patients and methods: 60 female patients having proven omental deposits from gynecological malignancies underwent PET/CT examination following a preset protocol as baseline study. 34 cases of them had a second PET/CT examination following same protocol after 5–11 months considered as first setting follow up study aiming to assess therapeutic response.

Results: Out of 34 cases 2 cases (6%) showed only newly developed lesions, 8 cases (23.5%) showed progression, 8 cases (23.5%) showed mixed response and 16 cases (47%) showed regression or complete resolution. In first setting follow up examination $^{18}$F-FDG PET/CT showed 31 TP, 2 TN and 1 FN cases while CT showed 29 TP, 2 TN, 2 FN and 1 FP cases. $^{18}$F-FDG PET/CT vs. CT revealed sensitivity, specificity and accuracy of 96.88% vs. 93.55%, 100% vs. 66.67% and 97.06% vs. 91.18% respectively.

Conclusion: $^{18}$F-FDG PET/CT is more accurate than CT in assessment of therapeutic response of proven gynecological malignancies omental deposits in first setting follow up.

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1. Introduction

The abdominal cavity and organs have serous membranous lining called peritoneum (parietal and visceral). The omentum and mesentery are double folds of peritoneum supporting bowel and attached to dorsal abdominal wall or other organs [1].

Gynecological malignancies spread via three different routes: peritoneum, lymphatic system, and blood stream. The peritoneum is the most frequent route of disease spread [2].

Omental deposits present with different morphological features, ranging from tiny nodular lesions of few millimeters diameters to large bulky nodular mass (omentum cake). Other typical features are scalloping of liver surface, reticular or nodular patterns due to invasion of mesenteric fat, and stellate pattern if mesenteric root is pulled down [3].

Metastatic omental lesions are one of the most significant prognostic factors [4] and therefore accurate diagnosis, staging, and monitoring of treatment response are of high importance [5]. Accurate localization, assessment of distribution and extent are paramount for surgical and biopsy purposes [6].

Surgical exploration (laparotomy or less invasive laparoscopy) is the gold standard for quantification of omental deposits [7]. No non-invasive diagnostic tool has been shown to be superior to exploratory laparoscopy/laparotomy [8].

PET and PET/CT have been reported as useful imaging modalities for the detection of distant metastases in ovarian and uterine cancer [9,10]. In comparison to conventional follow up with CT/MRI or serum biomarkers, $^{18}$F- FDG PET/CT provides a higher sensitivity, specificity and accuracy [9].

The objective of this study was to compare the diagnostic performance of $^{18}$F-FDG PET/CT scan and CT scan in follow up of proven gynecological malignancies omental deposits in first setting follow up after treatment.

2. Patients and methods

2.1. Patients

The study was approved by the local ethical committee. A prospective study of 60 female patients aged 32–71 years old (with...
Table 1
Different pathologies encountered in the study at baseline study, n (%).

<table>
<thead>
<tr>
<th>Pathology</th>
<th>Pre operative</th>
<th>Post operative</th>
<th>Post operative and therapy (chemotherapy &amp;/or radiotherapy)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ovarian tumour (44 patients)</td>
<td>4 (6.7%)</td>
<td>35 (58.3%)</td>
<td>5 (8.3%)</td>
</tr>
<tr>
<td>Uterine tumour (16 patients)</td>
<td>3 (5%)</td>
<td>6 (10%)</td>
<td>7 (11.7%)</td>
</tr>
<tr>
<td>Total (60 patients)</td>
<td>7 (11.7%)</td>
<td>41 (68.3%)</td>
<td>12 (20%)</td>
</tr>
</tbody>
</table>

Table 2
Different therapeutic responses in all cases at first setting follow up after 5–11 months, n (%).

<table>
<thead>
<tr>
<th>Pathology</th>
<th>Regression or complete resolution</th>
<th>Progression</th>
<th>Newly developed</th>
<th>Mixed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ovarian Tumour</td>
<td>16 (47%)</td>
<td>6 (17.5%)</td>
<td>2 (6%)</td>
<td>6 (17.5%)</td>
</tr>
<tr>
<td>Uterine Tumour</td>
<td>0 (0%)</td>
<td>2 (6%)</td>
<td>0</td>
<td>2 (6%)</td>
</tr>
<tr>
<td>Total</td>
<td>16 (47%)</td>
<td>8 (23.5%)</td>
<td>2 (6%)</td>
<td>8 (23.5%)</td>
</tr>
</tbody>
</table>

Fig. 1. A 55-year-old female patient with pathologically proven malignant germ cell tumour consistent with juvenile granulosa cell tumour. Baseline study 3 weeks post left adnexectomy: (a) Coronal fused PET/CT image and (b) Coronal MIP PET image. No evidence of metabolically active local tumoural residue or distant metastatic spread. First setting follow up after 6 months: (c) Axial post contrast CT, (d) and (e) Axial fused PET/CT images. Newly developed focal FDG-avid omental nodule beneath anterior abdominal wall supra-umbilical region measuring 1.9 cm in diameter with SUVmax 2.6 (arrows) and focal FDG-avid omental nodule in line with the previous abdominal incisional scar measuring 1.5 cm in diameter with SUVmax 3.4 (arrow head).
mean age of 52 years old) presenting to a private specialized medical center with proven omental deposits from gynecological malignancies coming for staging was performed during 10 months duration. 34 cases of them had a second PET/CT examination following same protocol after 5 to 11 months during 14 months duration aiming to assess the therapeutic response after surgical intervention, chemotherapy, radiotherapy or combined treatment.

There were no set criteria for referral other than histopathologic evidence of omental secondary deposits after biopsy or surgery. Patients had clinical evaluation including medical history. Information regarding serum markers levels, intervention, surgeries and biopsies was obtained from all cases.

All images were reconstructed using dedicated workstations and software. Results were correlated with serum tumour markers and histopathological findings.

2.2. Methods

Two PET/CT scan examinations following same protocol were obtained for each patient. The first study was considered as baseline study and the second examination was considered as first setting follow up. They were scanned using a dedicated PET system (Siemens Syngo PET VG 50A Biograph 20 VA 44A, Berlin, Germany), covering an axial field-of-view (FOV) of 15.2 cm and a resolution of 3 mm axially and 3.5 mm trans axially at the centre.

All patients fasted for 6 h before the examination and were hydrated orally. Blood glucose levels were assessed and found to be within normal range in all cases before the study. First non contrast low dose CT images were obtained for fusion images. A 310–450 MBq ($^{18}$F-FDG) were injected and the patients rested for an uptake period of 45 min in relaxed position. After emptying the bladder, PET scans from the nose to the upper thighs were acquired.

Routine axial imaging, consisting of CT of the chest, abdomen and pelvis at 3 mm intervals after intravenous non ionic contrast administration was performed in all patients after they finished the PET/CT examination.

2.3. Data analysis and interpretation

The raw data were reconstructed using special workstations and software. All images were reconstructed in sagittal and coronal multiplanar planes and read visually.

All PET/CT and CT imaging was performed and evaluated by one staff radiologist with expertise in gynecological imaging accompanied by one staff nuclear medicine. SUV values were compared to background vasculature to determine positivity and all foci of unphysiologic FDG uptake were considered indicative of metastatic disease.

For the purposes of calculating sensitivity, specificity and predictive values, true positive cases were confirmed by histopathology obtained after open surgery or biopsy. True negatives were validated by normal levels of serum tumour markers using the well established marker CA-125. False positives and negatives were defined by histopathological findings contrary to CT or PET/CT results.

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**Fig. 2.** A 49-year-old female patient with pathologically proven malignant ovarian tumour. Baseline study post operative and chemotherapy: (a) Axial fused PET/CT image, (b) Axial post contrast CT image and (c) Coronal MIP PET image. Hypermetabolic sheet-like and nodular omental thickenings beneath the anterior abdominal wall, gastro-splenic region and involving the hepatic and splenic reflections. The left hypochondrial lesion measures $2 \times 1$ cm in diameter with SUVmax 23.5. First setting follow up post chemotherapy after 8 months: (d) Axial fused PET/CT image, (e) Axial post contrast CT image and (f) Coronal MIP PET image. Progressive course regarding the sizes and numbers of sheet-like and multiple omental nodules/masses. The most active at the left hypochondrial region measuring $3.4 \times 1.7$ cm in diameter with SUVmax 37.3 (arrows).
3. Results

Baseline studies were performed for 60 female patients. 44 cases (73.3%) had ovarian tumours and 16 cases (26.7%) had uterine tumours.

7 cases (11.7%) were in pre operative state, 41 (68.3%) were in post operative and therapeutic state whether chemotherapy, radiotherapy or combined treatment as listed in Table 1.

34 cases had their first setting follow up study after 5 to 11 months, 30 cases (88.2%) had ovarian tumours and 4 cases (11.8%) had uterine tumours.

Different therapeutic responses were recorded as listed in Table 2.

2 cases (6%) had baseline study free of omental deposits or distant metastasis and showed newly developed omental metastasis in first setting follow up study (Fig. 1).

8 cases (23.5%) showed multiple omental deposits in baseline study and progressions regarding their sizes and numbers in first setting follow up study (Fig. 2).

8 cases (23.5%) showed multiple omental deposits in baseline study and mixed response in the first setting follow up study as some of them regressed or disappeared while on the other hand there was progression in other lesions or newly developed ones (Fig. 3).

16 cases (47%) showed omental deposits in baseline study and recorded regression regarding their sizes and numbers in first set-

![Baseline study (pre operative)](image)

![First setting follow up post operative and chemotherapy (after 9 months)](image)

Fig. 3. A 47-year-old female patient with pathologically proven malignant ovarian tumour. Baseline study pre operative: (a) Axial post contrast CT image, (b) Axial MIP PET image, (c–f) Axial fused PET/CT images and (g) Coronal MIP PET image. Multiple omental masses and infiltrates at right subhepatic, peri-hepatic, peri-splenic, gastro-splenic, bilateral para-colic gutters, mesenteric, serosal surface of bowel and pelvic reflections. Maximum SUV 17.3 along the postero-inferior surface of the liver opposite segment VI measuring 4.8 cm in diameter. First setting follow up post operative and chemotherapy after 9 months: (h) Axial post contrast CT image, (i) Axial MIP PET image, (j–m) axial fused PET/CT images and (n) Coronal MIP PET image. Mixed response of widespread omental masses. The previously noted most active lesion related to postero-inferior surface of the liver has resolved (arrow in image f) with regression of many other lesions. Nevertheless, other lesions have progressed as with the infiltration beneath the abdominal wall and left lumbar regions (dashed circle in image l) (SUVmax 13.2 compared to 7.6 in baseline study).
**Baseline study (1 month post operative)**

Fig. 4. A 62-year-old female patient with pathologically proven malignant ovarian tumour. Baseline study 1 month post operative: (a) Axial fused PET/CT image, (b) Axial post contrast CT image, (c) Axial MIP PET image and (d) Coronal MIP PET image. Multiple omental nodular masses and sheet like thickenings at peri-hepatic, sub-hepatic, peri-splenic, right para-colic, underneath the anterior abdominal wall, serosal and pelvic peritoneal reflections, the most active is sub-hepatic measures 2.8 cm in diameter with maximum SUV 9.6. First setting follow up post chemotherapy after 5 months: (e) Axial fused PET/CT image, (f) Axial post contrast CT image, (g) Axial MIP PET image and (h) Coronal MIP PET image. Metabolic and morphologic regression of previously noted abdominal and pelvic omental deposits, the most active recorded at sub-hepatic region with SUVmax 7.3.

**First setting follow up post chemotherapy (after 5 months)**

**Baseline study (1 month post operative)**

**First setting follow up post chemotherapy (after 7 months)**

Fig. 5. A 54-year-old female patient with pathologically proven malignant ovarian tumour. Baseline study 1 month post operative: (a) Axial post contrast CT images, (b) Axial fused PET/CT images, (c) Axial MIP PET images and (d) Coronal MIP PET image. Widespread irregular hypermetabolic sheet-like and nodular omental infiltrates involving hepatic reflections (causing scalloping on hepatic surface with SUVmax 6.0), at porta-hepatis, beneath abdominal wall (SUVmax 8.1), in the pelvic reflections (SUVmax 8.7) and left para-colic gutter. Partially encysted abdominal ascites showing low grade FDG activity is also noted. First setting follow up post chemotherapy after 7 months: (e) Axial post contrast CT images, (f) Axial fused PET/CT images, (g) Axial MIP PET images and (h) Coronal MIP PET image. Complete metabolic response with remarkable morphologic regression of previously noted abdominal and pelvic omental deposits. Residual sheets in left hypo-chondruium and along posterior pelvic peritoneal reflection as well as sub-diaphragmatic perihepatic ascites with no FDG-activity.
ting follow up study (Fig. 4) or complete resolution if the lesions disappeared (Fig. 5).

In first setting follow up examination 18F-FDG PET/CT showed 31 true positives, 2 true negatives, 1 false negative and no false positive cases while CT showed 29 true positives, 2 true negatives, 2 false negative and 1 false positive cases. They were identified based on subsequent clinical, laboratory, imaging and histopathological validation.

The true negative patients had no evidence of residual active operative bed masses or active distant metastasis and had within normal serum tumour markers levels.

The CT false negative cases in first setting follow up study showed no evidence of omental deposits contrary to PET/CT which showed multiple scattered FDG avid omental soft tissue lesions proved subsequently by histopathology to be secondary metastasis (Fig. 6).

The CT false positive case in first setting follow up study showed left side of the pelvic cystic marginally enhancing lesion that was considered as omental deposit. PET/CT study showed low grade activity and the lesion was considered as encysted fluid collection, a finding that was subsequently confirmed by histopathology (Fig. 7).

The PET/CT false negative case in first setting follow up study showed no evidence of FDG avid lesions contrary to CT which showed multiple sheet like omental soft tissue lesions at pelvic reflections proved subsequently by histopathology to be omental deposits (Fig. 8).

![Baseline study (1 month post operative)](image)

![First setting follow up (after 6 months)](image)

**Fig. 6.** A 39-year-old female patient with pathologically proven malignant ovarian tumour. Baseline study 1 month post operative: (a) Axial post contrast CT images, (b) Axial MIP PET images and (c) Axial fused PET/CT images. No evidence of metabolically active local tumoural residue or distant metastatic spread. First setting follow up after 6 months: (d) Axial post contrast CT images, (e) Axial MIP PET images and (f) Axial fused PET/CT images. Multiple hypermetabolic FDG-avid small omental soft tissue nodules in the mesentery and pelvic reflections (arrows in images e and f). These were not detectable in post contrast CT examination (images d) and this case was considered as one of CT false negative cases.
Fig. 7. A 52-year-old female patient with pathologically proven malignant ovarian tumour. Baseline study 1 month post operative: (a) Coronal fused PET/CT images and (b) Coronal MIP PET image. Increased FDG uptake by the thyroid gland. No evidence of metabolically active local tumoural residue or distant metastatic spread. First setting follow up after 5 months: (c) Axial and sagittal post contrast CT images, (d) Axial and sagittal fused PET/CT images and (e) Axial and sagittal MIP PET image. CT revealed left pelvic small cystic soft tissue lesion with enhancing wall measuring about 2.8 x 2.1 cm in diameters. PET study showed low grade FDG uptake with SUV max 2.1 and this case was considered as the CT false positive case.

Fig. 8. A 55-year-old female patient with pathologically proven malignant ovarian tumour. Baseline study 3 months post operative: (a) Coronal post contrast CT images, (b) Coronal fused PET/CT images and (c) Coronal MIP PET image. No evidence of metabolically active local tumoural residue or distant metastatic spread. First setting follow up after 6 months: (d) Axial post contrast CT images, (e) Axial fused PET/CT images and (f) Axial MIP PET image. CT revealed operative bed soft tissue thickenings along pelvic peritoneal reflections (arrows in image d). There was no significant corresponding FDG uptake and this case was considered as the PET/CT false negative case.
\(^{18}\text{F}-\text{FDG PET/CT}\) vs. CT showed sensitivity, specificity and accuracy of 96.88\%, 100\% and 97.06\% respectively preceding those of Soussan et al. [12] who reported sensitivity and specificity of 84\% and 73\%, respectively, for 18F-FDG PET/CT in a series of 30 patients. In a study performed by Pfannenberg et al. [13], they studied 22 patients and found a strong correlation (r = 0.951) between peritoneal carcinomatosis index (PCI) obtained by 18F-FDG PET/CT and surgical PCI, superior to that shown by 18F-FDG PET and CT alone. Recently, two meta-analysis concluded that 18F-FDG PET/CT is a powerful imaging technique for detection and characterization of omental deposits [14,15].

On the other hand few studies reported contrary results as Dromain et al. [16] analyzed 28 patients and found that the sensitivity of 18F-FDG PET/CT was 57\%. Lopez et al. [17] concluded that CT was a better diagnostic test than 18F-FDG PET/CT to confirm the presence of omental lesions after studying 59 patients whose PCI have been determined by preoperative radiological CT and 18F- FDG PET/CT and compared with surgical PCI.

Many studies compared 18F-FDG PET/CT and CT in the evaluation of omental metastasis from gynecological malignancies. These studies assessed the omentum during initial staging, post therapeutic follow up and in cases of suspected recurrence. The results obtained were controversial due to the wide variety of methods used when comparing 18F-FDG PET/CT findings with surgical findings, histopathological findings, CT/US guided biopsies and marker levels. In order to overcome this problem, the results of 18F-FDG PET/CT and CT in this study were compared in two consecutive examinations following the same imaging protocol with fixed time interval range.

The reference used to compare the imaging results was variable in many studies. Castelluci et al. [18], Kim et al. [19] and Schmidt et al. [20] used the histological findings of the resected pieces claiming that this is most accurate and reported superior results of 18F-FDG PET/CT over CT. Lopez et al. [17], Funicelli et al. [21] and Hyninnen et al. [22] believe that the surgical PCI should be the gold standard particularly if the patient was treated with chemotherapy before surgery as the deposit could be completely devitalized, giving negative result in the histological analysis but not in operative evaluation. They registered similar or superior results of CT over 18F-FDG PET/CT.

Cytoreduction and hyperthermic intra operative intra peritoneal chemotherapy (HIPEC) is an aggressive surgery in order to achieve complete resection in advanced ovarian cancer with peritoneal dissemination [23,24]. Preoperative accurate identification of the disease in these patients is essential as the therapeutic approach will be based largely on imaging findings [25]. This technique requires accurate peritoneal assessment for the presence or absence of deposits, their exact extent, locations and sizes raising the importance of 18F-FDG PET/CT as a powerful imaging technique for detection and characterization of peritoneal lesions.

The evaluation of the omental lesions, although it is very sensitive in terms of tracer uptake, the interpretation may be hampered by the intestinal physiologic uptake and activity. Measurement errors can be present as SUV levels are obtained manually. Respect to waiting period of minimum 2 weeks after the completion of chemotherapy should be accomplished before performance of PET/CT.

In conclusion \(^{18}\text{F}-\text{FDG PET/CT}\) is more accurate than CT in assessment of therapeutic response of proven gynecological malignancies omental deposits in first setting follow up as it provides valuable data about the presence and extent of omental deposits as well as their sizes and locations. Therefore it has a major role in deciding upcoming further management plans.

References


[12] Soussan M, Wartski M, Cherel P, Fourme E, Goupil A, Le Stanc E, et al. Impact of 18F-FDG PET/CT vs. CT showed sensitivity, specificity and accuracy of 18F-FDG PET/CT over CT. CT, US guided biopsies and markers levels. In order to overcome this problem, the results of 18F-FDG PET/CT and CT in this study were compared in two consecutive examinations following the same imaging protocol with fixed time interval range.


