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FULL PAPER

Benefits of fluorine-18 fludeoxyglucose positron emission tomography in secondary cytoreductive surgery for patients with recurrent epithelial ovarian cancer

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Objective: To investigate the benefits of fluorine-18 fludeoxyglucose positron emission tomography (¹⁸F-FDG-PET) in patients undergoing secondary cytoreductive surgery (SCRS) for recurrent epithelial ovarian cancer.

Methods: Patients were identified, and their clinical information was extracted by review of the gynaecologic oncology database of Peking Union Medical College Hospital. ¹⁸F-FDG-PET scan and analysis were performed by nuclear medicine experts at our hospital.

Results: The PET group and the control group of patients evaluated by conventional imaging methods differed significantly with respect to the proportion of patients who underwent complete SCRS and the number of residual lesions ($p = 0.002$ and 0.006 , respectively). A Cox model showed that longer progression-free survival (PFS) correlated significantly with ¹⁸F-FDG-PET evaluation

[relative risk (RR) = 0.432; $p = 0.001$], sensitivity to platinum-based chemotherapies (RR = 0.604; $p = 0.034$) and resection completeness (RR = 0.679; $p = 0.039$). Longer overall survival (OS) correlated significantly with sensitivity to platinum-based chemotherapy (RR = 0.317; $p = 0.000$) and the CA-125 level after two cycles of chemotherapy (RR = 2.663; $p = 0.003$). Surgical safety and complications did not significantly differ between the two groups of patients.

Conclusion: ¹⁸F-FDG-PET is useful for evaluating patients with recurrent epithelial ovarian carcinoma. Patients who undergo PET-guided SCRS have a greater chance of complete tumour resection and a longer PFS.

Advances in knowledge: SCRS guided by PET results in fewer residual lesions. PET-guided SCRS is safe and can prolong PFS and OS in patients with recurrent ovarian cancer.

Epithelial ovarian cancer (EOC) is one of the most common malignancies of the female genital tract. Since most patients have advanced-stage disease at the time of diagnosis and the incidence of recurrence is very high, only 30–40% of patients with EOC survive 5 years or more.^{1,2} Recurrent EOC is difficult to treat and regarded as incurable³ because of insufficiently effective treatments. Patients with recurrent EOC are typically treated with second-line chemotherapy, secondary cytoreductive surgery (SCRS), target therapy and radiation, none of which has been proven to be effective in all cases. An individualized management strategy is therefore commonly used for recurrent EOC, but reliable stratification of these patients to identify those who would benefit from a particular treatment is urgently needed.

Although SCRS is one of the important methods used to treat recurrent EOC, its benefits are controversial.^{4–6} A recent study demonstrated that SCRS increases overall survival (OS) in selected patients with recurrent EOC.⁷ As with optimal primary cytoreductive surgery (residual tumour ≤ 1 cm), which is associated with a better prognosis, among patients undergoing SCRS, an optimal surgical procedure, defined as the achievement of complete resection, is independently associated with the overall post-recurrence survival time.^{7–9} Therefore, SCRS should aim at removing all macroscopic disease. However, based on present data and evidence, the best method to identify suitable candidates for SCRS and to offer preoperative guidance allowing a thorough surgical procedure has yet to be definitively determined.

With advances in functional imaging, fluorine-18 fludeoxyglucose positron emission tomography (^{18}F -FDG-PET) has undergone a paradigmatic shift in its use as a diagnostic imaging tool in oncology. Thus, ^{18}F -FDG-PET and CT (PET/CT), by providing both functional and anatomical information, are now widely used in the diagnosis, staging, recurrence assessment, response evaluation and prognosis of ovarian cancer.^{10–13} However, whether ^{18}F -FDG-PET is better than other conventional forms of evaluations, including type-B ultrasonography (BUS), CT and MRI, in predicting and guiding an optimal SCRS has been insufficiently evaluated. Therefore, in this study, we investigated the role of ^{18}F -FDG-PET and PET/CT in selecting suitable patients for SCRS and the ability of these imaging methods to predict and guide a thorough and safe surgical procedure. Specifically, we determined the completeness and safety of ^{18}F -FDG-PET when used in SCRS by comparing the survival outcomes of these patients with those who underwent SCRS guided by the above-mentioned conventional imaging modalities.

METHODS AND MATERIALS

Patients

From 1 January 2001 to 31 December 2013, patients who underwent SCRS in our hospital subsequent to a diagnosis of recurrent EOC were identified by computerized review of the gynaecological oncology databases of our hospital. The inclusion criteria were (1) the pathological diagnosis of EOC confirmed independently by two pathologists in our hospital, (2) standard primary surgery (surgical staging or cytoreductive surgery) at either our or another hospital, (3) standard platinum-based chemotherapy after primary surgery, resulting in complete remission before disease recurrence and (4) preoperative evaluation using ^{18}F -FDG-PET or PET/CT at our hospital before SCRS (the PET group) or conventional imaging methods (the control group). Routine imaging evaluation by CT, MRI or BUS was allowed for patients in either group.

^{18}F -FDG-PET images were read by two nuclear medicine experts and their interpretation determined by consensus.

In our clinical practice, we usually suggest that patients with recurrent EOC who, following physical examination, BUS, CT or MRI, are regarded as suitable candidates for SCRS undergo a further preoperative ^{18}F -FDG-PET evaluation to determine the thoroughness and safety of SCRS. Patients with a continuously increasing serum CA-125 level but negative conventional imaging results are similarly recommended for ^{18}F -FDG-PET evaluation. However, because ^{18}F -FDG-PET is much more expensive than conventional imaging methods and is currently not covered by public medical insurance, some of these patients refused participation in the study either because of economic or private reasons. Therefore, according to the above criteria, 103 of the patients who underwent ^{18}F -FDG-PET evaluation before SCRS were included in the PET group. The control group consisted of the same number of age-matched patients without PET evaluation. The completeness and safety of SCRS and the prognosis after SCRS were compared between the two groups.

Data collection and definitions of the main observations

From the database, the following clinical information was extracted: age, the International Federation of Gynecology and Obstetrics (FIGO) staging, tumour histology, differentiation, type of operation, surgical complications, adjuvant treatment, time to and location of the recurrence and the status at last follow-up.

Complete remission after primary treatment was defined as no objective evidence of disease, including negative physical examination, normal serum CA-125 level ($<35 \text{ U l}^{-1}$) and negative CT scan without enlarged lymph nodes 1 cm or more in the short axis after the end of primary cytoreductive surgery and following platinum-based chemotherapy.

Table 1. The stage details of two groups

Stage	Positron emission tomography/CT group		Control group	
	Numbers	Percent (%)	Numbers	Percent (%)
Ia	1	0.97	3	0.29
Ib	1	1.0	0	–
Ic	5	4.8	2	1.9
IIa	0	–	0	–
IIb	0	–	0	–
IIc	7	6.8	8	7.8
IIIa	0	–	1	1.0
IIIb	3	2.9	3	2.9
IIIc	71	68.9	71	68.9
IV	12	12.0	11	11.1
Unknown	3	2.9	4	3.9

The presence of at least two of the following indicators after complete remission was considered as evidence of recurrence:^{3,14}

(1) continuously rising serum CA-125 level, (2) tumour growth proven either by imaging studies (BUS, chest/abdominal/pelvic CT, MRI, ¹⁸F-FDG-PET) or by physical examination, (3) newly appeared pleural effusion or ascites, (4) intestinal obstruction of undetermined reason and (5) any other evidence of recurrence as confirmed by pathology.

A platinum-sensitive patient was defined as a patient whose tumour relapsed 6 months or more after complete remission and a platinum-resistant patient as one whose tumour relapsed less than 6 months after complete remission. Progression-free survival (PFS) was calculated as the period from the date of SCRS to tumour recurrence or progression. OS was defined as the period from the date of diagnosis until the death of the patient or, for the survivors, the last follow-up.

To determine whether ¹⁸F-FDG-PET is better than conventional imaging methods in guiding an optimal and safe SCRS, the primary observation points of the study were the completeness of ¹⁸F-FDG-PET-guided SCRS and its complications. The thoroughness of the operation was graded as follows: (1) complete resection: removal of all disease without remaining macroscopic residual tumour, (2) optimal cytoreduction: residual disease 1 cm or less and (3) suboptimal cytoreduction: residual disease >1 cm. To assess whether, by guiding SCRS, ¹⁸F-FDG-PET improved the prognosis of patients with recurrent EOC, the secondary observation points were PFS and OS after PET-guided SCRS.

Fluorine-18 fludeoxyglucose-positron emission tomography scanning and analysis

Prior to receiving an intravenous injection of 1.5–2.0 MBq ¹⁸F-FDG/kg for ¹⁸F-FDG-PET scanning, all patients had fasted for at least 4 h and their blood glucose level was confirmed to be <200 mmol l⁻¹.

¹⁸F-FDG-PET imaging before 1 June 2008 (*n* = 28) was carried out using an ECAT EXACT HR+ PET system (Siemens Medical Solutions, Knoxville, TN). Subsequently, a Biograph® 64 Truepoint TrueV system (Siemens Medical Solutions) was used for the examination (*n* = 75). The contribution of the different ¹⁸F-FDG-PET imaging modalities to the final results was analysed.

Patients with only one or a limited number of tumours restricted to the abdominal cavity and with at least one tumour 2 cm or more were considered eligible for SCRS. Patients with diffusely distributed small lesions or with metastasis outside the abdominal cavity were considered unsuitable for SCRS.

Statistical analyses

The statistical analysis was performed using SPSS® software v. 17.0 (SPSS Inc., Chicago, IL). A *p*-value of <0.05 was considered to indicate statistical significance. A χ^2 test was used to compare the number of different preoperative imaging methods, platinum sensitivity, the proportion of complete resection and the number of complications. Fisher's exact test was used to compare the number of cases of EOC recurrence, as determined according to the above-described indicators. Student's *t*-test and the Mann–Whitney rank test were used to compare patient age, FIGO tumour stage, number of residual lesions, duration of the operation and volume of bleeding. A Kaplan–Meier survival

Figure 1. Number of residual lesions after secondary cytoreductive surgery.

Table 2. Progression-free survival (PFS) of the positron emission tomography (PET)/CT and control group

Group	Median PFS (months)	95% confidence interval		<i>p</i> -value
		Lower bound	Upper bound	
PET/CT group	20.0	12.9	27.1	0.04
Control group	9.0	7.2	10.8	
Total	13.0	9.8	16.2	

analysis and the Cox model analysis were used to evaluate the risk factors related to PFS and OS.

RESULTS

Characteristics of the patient population

The age range of the entire study population ($n = 206$) was 25–74 years (mean, 51.8 years). Patients in the PET and control groups had a mean age of 50.4 ± 10.1 years and 53.2 ± 11.0 years, respectively ($p = 0.054$).

Among the 206 patients, there were 4 patients (1.9%) with FIGO Stage Ia, 1 patient (0.5%) with Stage Ib, 7 patients (3.3%) with Stage Ic, 15 patients (7.2%) with Stage IIc, 1 patient (0.5%) with Stage IIIa, 6 patients (2.9%) with Stage IIIb, 142 patients (68.9%) with Stage IIIc and 23 patients (11.2%) with Stage IV disease; the remaining 7 patients (3.4%) had disease of unknown stage. The stage details of the two groups are summarized in Table 1 ($p = 0.918$).

All patients were diagnosed with EOC. Specifically, there were 152 (73.8%) patients with serous carcinoma, 5 (2.4%) with mucinous carcinoma, 18 (8.7%) with endometrioid carcinoma, 5 (2.4%) with clear cell carcinoma, 7 (3.4%) with transitional

cell carcinoma, 7 (3.4%) with mixed-components carcinoma and 12 (5.8%) whose tumour type was unknown. The distribution of tumour types between the PET and control groups was not significantly different ($p = 0.781$).

In the two groups of patients, 129 (62.6%) had platinum-sensitive and 59 (28.6%) had platinum-resistant disease; the platinum sensitivity status of the remaining 18 (8.7%) patients was unknown. There were no significant differences in the platinum sensitivities of the PET group *vs* the control group ($p = 0.695$).

Preoperative imaging evaluation of patients with epithelial ovarian cancer recurrence

In the PET group, the preoperative imaging evaluation before PET was carried out using BUS, CT or MRI in 38, 59 and 6 patients, respectively. In the control group, the corresponding numbers were 32, 67 and 4 ($\chi^2 = 1.422$; $p = 0.491$).

According to the recurrence indicators, in the PET group, there were 5 patients with tumour recurrence based on increasing CA-125 levels and intestinal obstruction, 10 patients with increasing CA-125 levels plus newly appeared pleural effusion/ascites,

Figure 2. Progression-free survival (PFS) curves of the positron emission tomography (PET) group and the control group.

Table 3. Overall survival (OS) of the positron emission tomography (PET)/CT and control group

Group	Median OS (months)	95% confidence interval		<i>p</i> -value
		Lower bound	Upper bound	
PET/CT group	43.0	31.9	54.1	0.008
Control group	22.0	9.6	34.4	
Total	38.0	27.1	48.9	

75 patients with increasing CA-125 levels and positive imaging results, 2 patients with intestinal obstruction plus newly appeared pleural effusion/ascites, 4 patients with intestinal obstruction plus positive imaging results, 1 patient with a recurrent tumour confirmed by pathology plus positive imaging results and 6 patients with newly appeared pleural effusion/ascites plus positive imaging results. In the control group, 1 patient was diagnosed with tumour recurrence based on increasing CA-125 levels plus intestinal obstruction, four patients had increasing CA-125 levels plus newly appeared pleural effusion/ascites, 81 had increasing CA-125 levels plus positive imaging results, 4 had intestinal obstruction plus newly appeared pleural effusion/ascites, 3 had intestinal obstruction plus positive imaging results, 6 had a recurrent tumour confirmed by pathology plus positive imaging results and 4 had newly appeared pleural effusion/ascites plus positive imaging results ($\chi^2 = 9.905$; $p = 0.118$).

Thoroughness of SCRS guided by ^{18}F -FDG-PET vs conventional imaging modalities

Of the 206 patients, 102 (49.5%) underwent complete resection of the recurrent tumour during SCRS, 62 (60.2%) in the PET group and 40 (38.8%) in the control group ($p = 0.002$). Optimal

cytoreduction during SCRS was achieved in 10 patients (9.7%) in the PET group and 10 (9.7%) in the control group ($p = 1.000$).

In both groups, residual disease scores varied from zero (no macroscopic residual disease) to seven. Patients who underwent ^{18}F -FDG-PET had significantly fewer ($p = 0.006$) foci of residual disease than patients who received conventional imaging (Figure 1).

The safety and complications of SCRS guided by ^{18}F -FDG-PET vs conventional imaging modalities

Duration of surgery

In the PET group, the mean and median duration of surgery was 167 ± 72 min and 160 min, respectively. The corresponding values for the control group were 187 ± 78 min and 175 min ($p = 0.070$).

Blood loss

In the PET group, the mean and median volume of blood loss during SCRS was 497 ± 569 ml and 300 ml, respectively. In the control group, the mean and median volumes were 462 ± 398 ml and 300 ml ($p = 0.882$), respectively.

Figure 3. Overall survival (OS) curves of the positron emission tomography (PET) group and the control group.

Surgical complications

After SCRS, there were 13 complications in 11 patients, 4 in the PET group and 7 in the control group ($p = 0.353$). There were four cases of incision infection, three of bowel leakage, two of intestinal obstruction, two of deep vein thrombosis, one of urine leakage and one of postoperative liver abscess. There were no surgery-related deaths.

The prognosis of the patients in the positron emission tomography vs the control group Prognostic advantages of preoperative ^{18}F -FDG-PET-guided SCRS

For the study population as a whole, the mean follow-up time after SCRS was 15.6 ± 3.4 months: 16.0 ± 5.1 months in the PET group and 14.3 ± 4.4 months in the control group ($p = 0.467$). During follow-up, 99 patients (48.1%) had persistent–progressive or recurrent disease, 43 (41.7%) in the PET group and 56 (54.3%) in the control group. As shown in Table 2 and Figure 2, PFS differed significantly in patients with PET-guided SCRS compared with those who had undergone

preoperative imaging using conventional imaging modalities ($p = 0.04$).

During the follow-up of all patients, the deaths of 75 (36.4%) could be attributed to the tumour, 27 (36.0%) in the PET group and 48 (64.0%) in the control group. As shown in Table 3 and Figure 3, the difference in the OS of PET-imaged and non-PET-imaged patients was significant ($p = 0.008$).

Preoperative ^{18}F -FDG-PET correlates with prolonged PFS after SCRS

The factors associated with a prolonged PFS are listed in Table 4. Together with platinum sensitivity, complete resection during SCRS and a normal CA-125 level ($\leq 35 \text{ U l}^{-1}$) after two cycles of postoperative chemotherapy, preoperative ^{18}F -FDG-PET evaluation correlated significantly with a longer PFS.

Multivariate analysis using the Cox model showed that, as with sensitivity to platinum chemotherapy [$p = 0.034$; relative risk (RR) = 0.604] and tumour complete resection

Table 4. Univariate analysis of the risk factors affecting progression-free survival (PFS)

Factors	Cases	Median PFS (months)	<i>p</i> -value
Age (years)			
<60	153	13.0	0.349
≥60	53	9.0	
International Federation of Gynecology and Obstetrics stage			
I and II	27	12.0	0.564
III and IV	172	13.0	
Platinum sensitivity			
Sensitive	129	14.0	0.015
Resistant	59	9.0	
Positron emission tomography/CT evaluation			
Yes	103	20.0	0.000
No	103	9.0	
Complete resection			
Yes	102	15.0	0.019
No	104	9.0	
CA-125 level after two cycles of postoperative chemotherapy ^a			0.006
≤35 U l ⁻¹	110	18.0	
>35 U l ⁻¹	60	7.0	
Surgical duration			
≤160 min	94	13.0	0.114
>160 min	112	13.0	
Bleeding volume			
≤300 ml	103	9.0	0.126
>300 ml	97	13.0	

^aPatients with normal CA-125 before secondary cytoreductive surgery were not included.

during SCRS [$p = 0.039$; relative risk (RR) = 0.679], preoperative ^{18}F -FDG-PET evaluation ($p = 0.001$; RR = 0.432) could prolong PFS significantly.

Preoperative ^{18}F -FDG-PET prolongs OS after SCRS

A univariate analysis of the risk factors influencing OS (Table 5) identified platinum sensitivity, preoperative evaluation methods, complete resection during SCRS, normal CA-125 level ($\leq 35 \text{ U l}^{-1}$) after two cycles of postoperative chemotherapy and preoperative evaluation by ^{18}F -FDG-PET as significantly correlating with longer OS.

However, in a multivariate analysis using the Cox model, preoperative evaluation by PET ($p = 0.079$; RR = 0.593) had no significant relation with OS, whereas sensitivity to platinum-based chemotherapy ($p = 0.000$; RR = 0.317) and a normal CA-125 level after two cycles of post-SCRS chemotherapy ($p = 0.003$; RR = 2.663) prolonged OS significantly.

The role of the positron emission tomography imaging system in outcome

As noted above, ^{18}F -FDG-PET (ECAT EXACT HR+ PET system) was used before 1 June 2008 and ^{18}F -FDG-PET/CT (Biograph 64 Truepoint TrueV system) thereafter. Thus, data acquired using the former were analysed separately. The results showed that between the PET group and control group, the difference in age ($p = 0.632$), tumour type ($p = 0.708$), FIGO stage ($p = 0.425$), thoroughness of SCRS ($p = 0.003$), complications owing to SCRS ($p = 0.546$), duration of SCRS ($p = 0.242$), blood loss during surgery ($p = 0.656$), number of residual tumours ($p = 0.000$), platinum sensitivity ($p = 0.720$), follow-up time ($p = 0.375$), PFS ($p = 0.018$) and OS ($p = 0.007$) were very similar to the results from the group of 206 patients as a whole.

DISCUSSION

Recurrent EOC is considered incurable, and the management of these patients remains a challenge for clinical practitioners. However, in well-selected patients with recurrent EOC, SCRS may

Table 5. Univariate analysis of the risk factors affecting overall survival (OS)

Factors	Cases	Median OS (months)	<i>p</i> -value
Age (years)			
<60	153	38.0	0.445
≥60	53	22.0	
International Federation of Gynecology and Obstetrics stage			
I and II	27	36.0	0.413
III and IV	172	38.0	
Platinum sensitivity			
Sensitive	129	42.0	0.002
Resistant	59	12.0	
Positron emission tomography/CT evaluation			
Yes	103	43.0	0.005
No	103	22.0	
Complete resection			
Yes	102	45.0	0.000
No	104	19.0	
CA-125 level after two cycles of postoperative chemotherapy ^a			
≤35 U l ⁻¹	110	42.0	0.000
>35 U l ⁻¹	60	14.0	
Surgical duration			
≤160 min	94	38.0	0.281
>160 min	112	21.0	
Bleeding volume			
≤300 ml	103	42.0	0.073
>300 ml	97	21.0	

^aPatients with normal CA-125 before secondary cytoreductive surgery were not included.

contribute to prolonging survival by reducing the tumour burden, relieve cancer-related symptoms and improve the quality of life.¹⁵ The DESKTOP-I trial, a well-designed multicentre retrospective study,^{16,17} showed that patients may benefit from SCRS if the recurrent tumour is resected completely. The results were well validated in the prospective DESKTOP-II trial.¹⁸ Thus, Harter *et al*⁶ pointed out that the surgical aim in recurrent EOC is complete resection of the tumour. This view was supported by a recent meta-analysis⁸ of more than 2000 patients. Therefore, in terms of surgical treatment of recurrent EOC, the key issues are (1) how to confirm the number of recurrent tumours and their extent, (2) how to select suitable patients who may benefit from SCRS and (3) how to preoperatively predict and increase the thoroughness and safety of SCRS.

Traditionally, the imaging methodologies used in selecting suitable patients for SCRS and in predicting the feasibility of SCRS have been BUS, CT and MRI,¹⁹ but their utility is limited in the evaluation of recurrent EOC. For instance, CT lacks the ability to detect a small volume of disease,¹⁹ MRI has a detection

rate comparable to CT but is more expensive²⁰ and BUS offers limited visibility.²⁰ Compared with these conventional imaging modalities, ¹⁸F-FDG-PET improves the selection of patients who may benefit from SCRS.^{21,22} According to the ¹⁸F-FDG-PET imaging criteria, eligible patients are those whose recurrent tumours are limited to the pelvic or abdominal cavity and can be separated from major organs or tissues (Figure 4). If the recurrent tumour has spread diffusely into the pelvic or abdominal cavity or is tightly adhered to major organs or vessels, these patients are not candidates for SCRS (Figure 5). In addition, ¹⁸F-FDG-PET is better at detecting recurrent smaller tumours, allowing earlier detection particularly when the only evidence of recurrence is a steadily increasing serum CA-125 level.²³ This capability of ¹⁸F-FDG-PET contributes to an easier and more thorough resection of a recurrent tumour. A previous study²⁴ demonstrated the ability of PET/CT to diagnose tumour recurrence even when the serum CA-125 level was low ($<30 \text{ U l}^{-1}$). Another study²⁵ showed that the value of PET/CT was similar to that of MRI in the detection of recurrent EOC and was even more accurate in the detection of peritoneal implants $<2 \text{ cm}$.

Figure 4. Positron emission tomography, CT and fusion images of recurrent ovarian cancer. The solitary lesion in the pelvis is a fine indication of secondary cytoreductive surgery.

Other studies^{21,22} demonstrated that PET/CT had much better overall sensitivity, specificity, accuracy and positive- and negative-predictive values than CT in the detection of recurrent EOC. The data above support the use of ^{18}F -FDG-PET or ^{18}F -FDG-PET/CT as a more specific and more sensitive tool than other imaging techniques in confirming the number and location of recurrent tumours. This ability recommends the use of PET and PET/CT to select patients who may benefit from SCRS.

Besides its superior ability in patient selection, ^{18}F -FDG-PET-guided SCRS can increase the thoroughness of SCRS when compared with BUS, MRI or CT. Our study showed that if the preoperative ^{18}F -FDG-PET evaluation suggested the resectability of the recurrent tumours, the actual thoroughness of recurrence resection during SCRS was 60.2% vs 38.8% with conventional imaging methods. The study of Kim et al²⁶ showed that PET/CT was superior to enhanced CT in the detection of peritoneal carcinomatosis. A retrospective study²³ of 34 patients found that PET/CT evaluation was beneficial in the detection of recurrence in patients with increased serum CA-125 levels and negative CT findings or patients with normal CA-125 levels but disease recurrence detected by CT. Those studies suggest that the improved surgical thoroughness of ^{18}F -FDG-PET is owing to its more accurate localisation of recurrent tumours²⁷ and its greater sensitivity²⁸ than other imaging methods, especially when ^{18}F -FDG-PET is combined with CT to afford both metabolic and anatomic information.

Further advantages of ^{18}F -FDG-PET-guided SCRS are its safety and low rate of complications. Our study showed that PET-

guided SCRS did not increase either the operation time or operative blood loss. The incidence and type of complications were similar in PET-guided and non-PET-guided SCRS. Therefore, the increased thoroughness was not achieved at the cost of compromised surgical safety or a decrease in the quality of life of these patients. Moreover, the ability of preoperative ^{18}F -FDG-PET to locate the recurrence accurately contributed to avoiding indiscriminate exploration during SCRS and thus reduced the probability of injury during the surgical process.

The survival analysis in our study revealed that, compared with patients treated using conventional imaging methods, those who underwent ^{18}F -FDG-PET-guided SCRS had improved PFS ($p = 0.04$) and OS ($p = 0.008$). The Cox model suggested that preoperative evaluation by ^{18}F -FDG-PET prolonged PFS. Specifically, since complete tumour resection in SCRS may also prolong PFS, ^{18}F -FDG-PET contributes to this improvement by increasing the probability of complete resection during SCRS. However, multivariate analysis using the Cox model showed that ^{18}F -FDG-PET-guided SCRS does not prolong OS significantly, suggesting that other factors are more important determinants of OS, such as sensitivity to platinum chemotherapy ($p = 0.000$; RR = 0.317) and the achievement of a normal CA-125 level after two cycles of post-SCRS chemotherapy ($p = 0.003$; RR = 2.663).

Our study had several limitations. First, because it was retrospective, some forms of bias, especially case selection bias, cannot be ruled out. Second, since not all primary CRS procedures were performed at our hospital, information about the

Figure 5. Positron emission tomography, CT and fusion images of recurrent ovarian cancer. The diffuse lesions in the pelvic and abdominal cavity are regarded as unresectable and not suitable for secondary cytoreductive surgery.

initial treatment was insufficient for some patients. Third, the study was performed at a single institution and not all patients eligible for ^{18}F -FDG-PET were enrolled in the PET group, for reasons specified herein. Hence, a multicentre, randomised, controlled and prospective study is needed to validate our results.

Nonetheless, our study showed that ^{18}F -FDG-PET is a valuable preoperative evaluation method that, compared with

conventional imaging modalities, can increase the probability of a complete tumour resection and therefore the PFS of patients with recurrent EOC who undergo SCRS. Both the safety and the complication rate of ^{18}F -FDG-PET-guided SCRS are satisfactory. We therefore recommend that all patients who are evaluated by conventional imaging modalities and determined to be candidates for SCRS should also be evaluated preoperatively with ^{18}F -FDG-PET or PET/CT.

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