Advanced Primary Epithelial Ovarian and Peritoneal Carcinoma—Does Diagnostic Accuracy of Preoperative CT Scan for Detection of Peritoneal Metastatic Sites Reflect into Prediction of Suboptimal Debulking? A Prospective Study

Kiran Bagul¹ · D. K Vijaykumar¹ · Anupama Rajanbabu¹ · Michelle Aline Antony¹ · Venkatesan Ranganathan¹

Received: 10 November 2015 / Accepted: 1 December 2016 / Published online: 18 February 2017
© Indian Association of Surgical Oncology 2017

Abstract Ovarian cancer is the seventh most common cancer in females worldwide. Optimal debulking is the standard treatment but possible only in 30–85% of advanced stages. Knowing exactly the disease extent preoperatively may predict suboptimal debulking. We analyzed diagnostic accuracy of preoperative CT scan in disease mapping and prediction of suboptimal debulking in a prospective observational study from March 2013 to May 2015 in a tertiary hospital. Adults below the age of 75 years with ECOG PS-0, 1, 2, clinically/radiologically newly diagnosed stage IIIc epithelial ovarian (EOC), and primary peritoneal carcinoma (PPC) were included. Neoadjuvant chemotherapy recipients were excluded. Preoperative multidetector CT (MDCT) scan showing deposits at 19 predetermined abdominopelvic sites were compared with the same sites seen at laparotomy and corresponding accuracies of CT scan calculated. Primary debulking surgery was done to achieve debulking to nil or less than 1-cm residual disease. Stepwise logistic regression models were used to determine the frequent suboptimal debulking sites and the predictive performance of the clinical and CT scan findings. A total of 36 patients were enrolled. The optimal debulking rate was 50%. The CT scan could detect the disease-bearing sites with overall sensitivity of 68.29%, specificity of 89%, accuracy of 78.07%, and positive and negative predictive values of 99 and 50.1%, respectively. Upon multivariate analysis, bowel mesentery (p 0.011) and omental extension (p 0.025) were associated with suboptimal debulking. CT scan accuracy at these sites

(predictive performance) was 86.1%. We identified small bowel mesentery and omental extension (to spleen/stomach/colon) as sites associated with suboptimal debulking. MDCT accurately depicts peritoneal metastases, although sensitivity is reduced in certain areas of significance for optimal debulking. Further validation with more number of patients is warranted.

Keywords Debulking surgical procedures · Ovarian cancer · Computed tomography · Diagnostic accuracy

Introduction

Epithelial ovarian cancer (EOC) is the seventh most common cancer in females worldwide and the second commonest gynecological malignancy [1]. A majority of patients (60 to 70%) present at an advanced stage (International Federation of Gynecology and Obstetrics [FIGO] stage III or IV) [2, 3]. Surgical debulking and platinum plus taxane-based chemotherapy are the standard treatments for these advanced cases with long-term cure rates of 20–30% [4, 5]. There is a large evidence demonstrating survival benefit for carcinoma ovary patients who are left with minimal (“optimal”) residual disease after the debulking procedure [6], with the recommendations of no gross visible residual disease at the end of debulking surgery [7].

However, in advanced cases, the rate of optimal cytoreduction at primary debulking surgery varies from 30 to 85% even in expert hands [8–12]. Patients who undergo suboptimal cytoreduction are at risk of the morbidity and mortality of an extensive surgery without the associated survival benefits. Hence, selection of patients for surgery represents a critical decision-making point in the management of these patients.

A lot of research have evolved in predicting the suboptimal debulking using various parameters like clinical characteristics

✉ Kiran Bagul
drkiranbagul@rediffmail.com; kirangb@aims.amrita.edu

¹ Department of Surgical Oncology, Amrita Institute of Medical Sciences, Ponekkara PO, Kochi, Kerala 682 041, India

[13], diagnostic imaging [14–17], laparoscopic findings [18], and biomarkers such as cancer antigen-125 (CA125) [19], imaging like computerized tomography (CT scan) [14–17, 20], with mixed results, variable applicability, and reproducibility [21, 22].

The present study prospectively analyzes the accuracy of various preoperative clinicobiochemical and imaging factors to exactly stage the disease distribution and compare this with intraoperative findings so as to predict suboptimal debulking.

Materials and Methods

This is a prospective observational study conducted between March 2013 and May 2015 at a single tertiary care center. Eligibility criteria were Eastern Cooperative Oncology Group performance status (ECOG PS) 0, 1, 2 and aged between 18 and 75 years with clinically diagnosed stage IIIc epithelial ovarian, fallopian tube, or primary peritoneal carcinoma (PPC) who were planned for primary debulking surgery. Patients were excluded if they had other cause of carcinomatosis; if they did not have advanced disease; or if they received neoadjuvant chemotherapy.

The schema of the study was as per the following steps:

1. Recording of preoperative demography and laboratory values.
2. Detailed recording of preoperative CT scan findings of disease distribution at 19 predetermined sites.
3. Detailed intraoperative assessment of disease distribution at 19 predetermined sites.
4. Correlation of the preoperative CT scan findings and the intraoperative findings of disease distribution (Objective 1).
5. Correlation of the intraoperative disease distribution and the rate of optimal/suboptimal debulking (identifying the sites of residual disease) (Objective 2).
6. Assessment of prediction of suboptimal debulking by preoperative clinical, laboratory, and imaging factors (Primary aim).

Preoperative CT Scans

CT scans were performed with a high-speed scanner—Siemens Somatom Sensation 64-slice MDCT (Siemens Medical Systems, Iselin, NJ). After oral administration, 40 ml of 2% Gastrografin contrast in 2 l of water, a CT scan was obtained at baseline and 30 s after intravenous administration of 80 ml of nonionic contrast at 2.3 ml/s rate. Images were obtained with 3–5 mm thickness and 15 mm/s table speed.

All the preoperative CT scans were systematically reviewed by the assigned radiologists before surgery who were blinded for the clinical decision of the treatment. The 19 potential sites of metastatic deposits included were the right

and left subdiaphragms, right and left paracolic regions, small and large bowel serosa, small and large bowel mesenteries, omental cake extension (to splenic hilum, stomach, colon, or lesser sac), parietal peritoneum, pelvic peritoneum, liver, spleen surface, porta hepatis, diffuse peritoneal thickening, retroperitoneal lymph nodes larger than 1 cm, and large-volume ascites. Large-volume ascites was defined as the presence of ascites on two thirds or more of abdominopelvic CT scan cuts. By omental extension, we mean omental cake extending and involving the spleen, stomach, lesser sac, or transverse colon requiring multivisceral resection to achieve optimal debulking. As described by Dowdy et al. [15], diffuse peritoneal thickening was defined as peritoneal thickening to 4 mm involving at least two of the five following areas: lateral paracolic gutters, lateral conal fascia, anterior abdominal wall, diaphragm, and pelvic peritoneal reflections. It was technically difficult to count the number of peritoneal deposits on CT scans and during surgery when there was diffuse carcinomatosis. Hence, while tabulating the findings, the presence of peritoneal deposits >2 cm in size in the respective sites was considered irrespective of actual number.

Surgical Management

All the patients were counseled regarding the nature of the surgery and possible complications. All the patients gave written consent for the study. The study was approved by the ethical committee of the institution.

All surgeries were performed within 2 weeks after the CT scan by three gynecologic oncologists. Standard procedures included midline laparotomy, surgical findings of disease distribution like site, size, pattern, and number of deposits (if countable) were recorded before starting of debulking; extrafascial hysterectomy, bilateral salphingo-oophorectomy, infragastric omentectomy, and systematic pelvic and paraaortic lymphadenectomy (only if complete tumor resection is possible at other sites). Optimal cytoreduction was defined as nil or less than 1-cm residual disease. Radical surgeries were done as appropriate to achieve optimal debulking.

The standard of reference for imaging and surgical findings was determined by combining each patient's surgical and histopathological findings.

Statistical Analysis

The chi square (χ^2) test was used to test the statistical significance of the association between preoperative clinical factors with the rate of optimal/suboptimal debulking. Validity parameters of preoperative CT scan compared to intraoperative findings were calculated for each site. The significance of the association between the operative findings of disease-bearing sites and optimal debulking rate was calculated with the chi square (χ^2) test. Univariate and multivariable stepwise

logistic regression models were used to determine the disease sites most frequently associated with suboptimal debulking. The level of significance was kept as 0.05.

Results

We analyzed 36 consecutive patients of stage IIIc epithelial ovarian and PPC undergoing primary debulking surgery on the basis of the eligibility criteria. Diagnosis and staging of all the patients were confirmed as per final pathological examinations. Patient and disease characteristics are shown in Table 1.

The mean age at presentation was 51 years (range of 39–74 years). The ECOG-PS of 0 and 1, and 2 was seen in 30 (83.3%) and 6 (16.7%), respectively. Most patients (88%) presented with nonspecific complaints (abdominal vague pains, insignificant weight loss, abdominal distension, bloating, and early satiety). Severe abdominal pain in three

(8.3%) and intestinal obstruction in one patient was seen at initial presentation. Clinically gross ascites was diagnosed in 26 (72.3%) patients and palpable abdominal mass in 18 patients (50%). Upon final histopathological examination, primary ovarian carcinoma and PPC were diagnosed in 31 (86%) and 5 (14%), respectively. The most common histology was serous papillary adenocarcinoma (55.5%). High-grade and low-grade lesions were seen in 27 (75%) and 9 (25%), respectively. All patients except one had raised CA125 (range 31 to 29,910 kU/l, median 702 kU/l). A CA125 of more than the cutoff for our study (500) was present in 19 (53%) patients.

At the end of the primary debulking surgery, optimal debulking to residual disease of less than or equal to 1 cm was achieved in 18 (50%) patients, out of which, debulking to no residual disease was possible in ten patients (27.7%). Average duration of surgery was 240 min (60–480 min). Average blood loss was 316 ml (110–900 ml) with an average 1.7 units of blood transfusion requirement. Additional complex procedures in the form of resectosigmoid resection (four), small bowel resection (three), splenectomy (three), and peritoneal stripping (seven) were done to achieve optimal debulking (total 47%). In six patients, surgery could not be completed due to intraoperative unstability (two) and anticipated suboptimal debulking due to extensive carcinomatosis upon initial surgical evaluation (four).

The rate of postoperative complications was 25%, these were reexploration for intraabdominal bleeding (one), postoperative chest congestion and lower respiratory tract infection (four), and wound infection (three). There was no mortality within 30 days after surgery.

Correlation of Clinical Factors with Debulking Rate

Clinically detected gross ascites was the only clinical factor associated with suboptimal debulking. p 0.050 on univariate analysis. No other factor like age, ECOG PS, CA125, histology, or grade was correlated with the surgical outcome. Patients with clinically detected gross ascites also had the simultaneous presence of disease at other sites like right subdiaphragmatic region (100%), left subdiaphragmatic region (81%), liver surface (73%), porta hepatic (69%), parietal peritoneum (80%), omental extension (69%), and small bowel mesentery (61.5%). The sensitivity, specificity, positive predictive value, negative predictive value, and accuracy for this clinical parameter in predicting suboptimal debulking result was 88.8, 44.4, 61.5, 80, and 66.6%, respectively.

Results of Objective 1 (Accuracy of CT Scan in Detection of Sites of Disease)

The correlation of the accuracy of CT scan findings of the sites of disease with respect to intraoperative findings is shown in Table 2. Diffuse peritoneal thickening on the CT scan matched

Table 1 Patient and disease characteristics

Characteristics	n (%)
Age (years)	
•Less or equals 50	18 (50)
•More than 50	18 (50)
ECOG PS	
•0, 1	30 (83.3)
•2	6 (16.7)
Menopausal status	
•Premenopausal	13 (36)
•Postmenopausal	23 (64)
Primary site	
•Ovarian carcinoma	31 (86)
•Primary peritoneal carcinoma	5 (14)
Histological type	
•Serous type	20 (55.5)
•Clear cell type	3 (8.3)
•Endometrioid type	2 (5.5)
•Mucinous	1 (2.7)
•Adenocarcinoma NOS	10 (27.7)
Grade	
•Low grade	9 (25)
•High grade	27 (75)
Clinical findings	
•Gross ascites	26 (72.3)
•Palpable mass	18 (50)
CA125 value (kU/l) median	702
• < 500	17 (47)
• > 500	19 (53)

ECOG PS Eastern Cooperative Group performance status, CA125 cancer antigen 125

Table 2 Performance of CT scan in detection of peritoneal deposits as compared to Staging Laparotomy (SL) findings

Site of peritoneal deposits	Disease on CT scan (n)	Disease on SL (n)	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	Accuracy (%)
Diffuse peritoneal thickening	17	17	100	100	100	100	100
Right subdiaphragm	32	35	91.43	100	100	25	91.67
Left subdiaphragm	22	27	81.4	100	100	35.7	81.6
Porta hepatis	9	24	37.5	100	100	44.4	58.3
Liver	18	25	72	100	100	61.1	80.5
Spleen	5	11	45.4	100	100	80.6	83.33
Lesser sac	8	15	53.33	100	100	75	80.55
Omentum (any amount)	34	35	97.1	100	100	50	97.2
Omentum extension	18	24	75	100	100	66.6	83.3
Right paracolic region	22	33	68.5	100	100	23.07	71.4
Left paracolic region	19	27	70.3	100	100	53.7	77.7
Small bowel serosa	8	20	35	93.7	87.5	53.5	61.1
Small bowel mesentery	11	21	52.3	100	100	60	72.2
Large bowel serosa	12	29	41.3	100	100	29.1	52.7
Large bowel mesentery	18	32	53.1	75	94.4	16.7	55.5
Uterus and ovary	33	34	100	100	100	100	100
Pelvic peritoneum	24	34	69.6	0	95.8	0	67.6
Urinary bladder peritoneum	16	32	51.6	100	100	16.7	56
Retroperitoneal Lymph nodes	9	12	81.8	100	100	92	94.1
Large-volume ascitis	34	36	94.4	0	100	0	94.4
Parital peritoneum	18	19	63.15	100	100	70.8	80.5
Overall	—	—	68.29	89	99	50.1	78.07

with the operative findings with 100% accuracy. The CT scan has high sensitivity in diagnosing deposits at both subdiaphragmatic regions, omentum, and retroperitoneal nodes (>80% sensitivity) whereas the CT scan's sensitivity in diagnosing disease at bowel serosa, mesentery, and porta hepatis was low (35 to 53%).

Results of Objective 2 (Analysis of intraoperatively Identified Sites and Pattern of Disease with the Rate of Suboptimal Debulking)

The univariate and multivariate analyses are shown in Table 3. Multivariate analysis showed deposits at small bowel

mesentery (p 0.011) and presence of omental extension (to spleen/stomach/colon/lesser sac) (p 0.025) as consistent with the suboptimal debulking rate. There is a trend towards significance for clinical ascites.

Discussion

This study reports the results from a prospective trial investigating the role of preoperative clinical and CT scan-based evaluation in the preoperative prediction of optimal debulking in advanced epithelial ovarian and primary peritoneal cancer.

Table 3 Univariate and multivariate analysis showing intraoperatively identified sites of disease and association with suboptimal debulking

Predictors of suboptimal debulking	Univariate analysis (p value)	Multivariate analysis (p value)
Small bowel mesentery (>2 cm)	0.041	0.011
Omental cake (extending to spleen, stomach, lesser sac)	0.034	0.025
Parietal peritoneum (>2 cm)	0.041	—
Small bowel serosa (>2 cm)	0.018	—
Diffuse peritoneal thickening (>4 mm thick)	0.007	—
Granular type of deposit (>2 cm)	0.027	—
Ascites on clinical examination	0.050	0.069

Fig. 1 Axial section of MDCT abdomen and pelvis with oral, rectal, and intravenous contrast showing upper abdominal peritoneal deposits at 1 cystic liver subcapsular lesion, 2 right subdiaphragmatic deposit, 3 gall bladder region, 4 lesser sac region, and 5 splenic region

In the present study, among the clinical factors, only clinically detected gross ascites was found to be significantly associated with suboptimal debulking (p 0.050). This is consistent with the theory of peritoneal carcinomatosis which is induced and propagated by ascitic fluid [23]. In a clinical study, Brockbank EC et al. [24] observed clinically diagnosed ascites along with other clinical parameters to be associated with suboptimal outcome. Eisenkop SM et al. [8] also demonstrated ascites of more than 1 l to be associated with suboptimal debulking.

Goff BA et al. [25] have observed symptoms, such as abdominal pain, abdominal distension and bloating, and early satiety as indicative of more advanced diseases especially upper abdominal disease. Such symptoms were present in 88% of our patients. But this parameter and other clinical factors like age, ECOG PS, CA125, histology, and tumor grade were not associated with surgical outcome. However, Aletti GD et al. [26] has cautioned the use of clinical factors in predicting surgical results in view of variable surgeon's experience and ability in approaching the debulking surgery. Still, these findings may at least give an indication of the presence of an advanced disease and the surgeon can be

prepared for further investigations and possible extensive surgery.

In the present study, the CT scan imaging could identify the disease at different locations as confirmed on surgical exploration with overall sensitivity of 68.29%, specificity of 89%, PPV of 99%, NPV of 50.1%, and accuracy of 78.07%. The highest detection rate was seen for the diffuse peritoneal thickening (100% sensitive) and lymph nodal region (94%) followed by the subdiaphragmatic region (91.6%) and omental extension (75%) (Table 2). This is comparable to the results of a prospective study by G Ferrandina et al. [27] where the accuracy of the CT scan in identification of sites of disease was 78.5% for diffuse peritoneal thickening, 79.2% for omental extension to spleen or stomach, 81.9% for infrarenal lymph nodes, and 67% for subdiaphragmatic deposits.

In the present study, the sensitivity was 72.5% for identifying deposits at upper abdominal sites (both subdiaphragmatic regions, liver, spleen, lesser sac, porta hepatis) (Fig. 1) and a low sensitivity was noted for bowel serosa and mesentery (35 to 53%) sites. These results are consistent with a similar study by Chandrashekhara et al. [28] where the sensitivity of the CT scan in finding the disease at upper abdominal sites was 74.8% compared to low sensitivity (33.3%) for the umbilical region (presumably the mesentery and bowel serosa). Table 4 shows previous studies showing the overall accuracy of CT scan in locating important disease-bearing sites.

In the present study, high specificity and positive predictive value of CT scan for the diagnosis of peritoneal metastases sites indicating that the rate of CT scan detected lesions being positive for metastasis is high.

Mere presence of omental cake can be resected in almost all the cases. But when the omental disease spreads to involve surrounding organs like transverse colon, lesser sac, stomach, spleen hilum or porta, it becomes difficult to resect and may need multivisceral resection to achieve optimal debulking. Similarly, multiple, large deposits at the root of mesentery precludes optimal debulking. Hence, finding disease at these two sites preoperatively or at the beginning of the surgery will predict the ultimate suboptimal outcome and avoid unnecessary debulking surgery with associated morbidity and mortality. Patients with this type of extensive disease may be treated

Table 4 Comparison of studies showing overall accuracy of CT scan for detection of disease bearing sites

Study	n	Sensitivity % (range)	Specificity %	PPV %	NPV %	Accuracy %
G Ferrandina et al. [27]	195	—	77.9	63.3	71.1	75.6
Chandrashekhara et al. [28]	38	61.5 (33–89)	92	75.2	88.2	87.15
Metser et al. [29]	156	81.2	98.1	92.6	94.7	94.3
Buy et al. [30]	38	63	100	100	52	74
Coakley et al. [31]	64	25–93	78–96	88–97	18–88	—
Present study	36	68.29 (35–100)	89	99	50.17	78.07

Table 5 Studies showing accuracy of CT scan in identifying sites of disease associated with suboptimal debulking

Predictors of suboptimal debulking	Study	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	Accuracy (%)
Small bowel mesentery	Bristow et al. [14]	33.3	100	100	58.8	65.9
	G. Ferrandina et al. [28]	–	69.6	83.3	61.1	72.6
	Present study	52.3	100	100	60	72.2
Omental extension	Bristow et al. [14]	42.9	85	75	58.6	63.4
	G. Ferrandina et al. [28]	–	87	87.6	42.8	79.2
	Present study	75	100	100	66.66	83.33

with neoadjuvant chemotherapy followed by interval debulking surgery which is claimed to downstage the disease and gives comparable survival results to primary debulking surgery [32]. The accuracy of CT scan in identifying these two sites in our study was comparable to previous studies as shown in Table 5.

The strengths of the study are as follows: This is a prospective study. Use of multidetector CT scan machine with thin cuts made easy and fairly accurate interpretation of the disease distribution. A different observation was made in this study about the pattern of disease like nodular, plaque-like, or granular type of deposits which is easy to identify intraoperatively (or by diagnostic laparoscopy). We could identify clinical factors like clinically detectable gross ascites which in association with other factors may predict suboptimal debulking. This particular finding which can be assessed on the first patient visit itself can give an indication for more thorough metastatic work-up and preparedness for extensive surgery.

A fewer number of patients can be a limiting factor in our study which precludes us from doing extensive analysis or proposing some index or model for predicting the surgical outcome. Nevertheless, we could show a few sites in the abdomen which are demonstrable on CT scan that are consistent with suboptimal surgical results. The debulking rate was low (50%). The reasons could be the low rate of radical procedures done (47%) to achieve optimal debulking and inability to complete the surgery in six patients due to not attempting debulking in anticipation of suboptimal debulking upon initial surgical staging evaluation (four patients) and due to intraoperative instability (two patients), thus underlines the importance of patient selection and surgical expertise.

Conclusions

We identified two peritoneal metastatic sites in the abdomen—small bowel mesentery and omental extension (to spleen, stomach, colon, lesser sac, or colon) which are associated with suboptimal debulking. MDCT scan is accurate in the depiction of peritoneal metastases, although sensitivity is reduced in certain areas of significance for optimal debulking. Clinically detected gross ascites can be a first indication of a

more extensive disease. A further study with more patients is warranted to more precisely draw conclusions.

Compliance with Ethical Standards All the patients were counseled regarding the nature of the surgery and possible complications. All the patients gave written consent for the study. The study was approved by the ethical committee of the institution.

Conflict of Interest The authors declare that they have no conflict of interest.

References

1. Ferlay J, Soerjomataram I, Ervik IM et al. (2013). GLOBOCAN 2012 v1.0, cancer incidence and mortality worldwide: IARC CancerBase No. 11 [Internet]. Lyon, France: International Agency for Research on Cancer. Available from <http://globocan.iarc.fr> date accessed-22/08/2015
2. Heintz AP, Odicino F, Maisonneuve P et al (2003) Carcinoma of the ovary. *Int J Gynaecol Obstet* 83(Suppl 1):135–166
3. Pecorelli S, Favalli G, Zigliani L et al (2003) Cancer in women. *Int J Gynaecol Obstet* 82:369–379
4. Armstrong DK, Bundy B, Wenzel L et al (2006) Intraperitoneal cisplatin and paclitaxel in ovarian cancer. *N Engl J Med* 354:34–43
5. Ozols RF, Bundy BN, Greer BE et al (2003) Phase III trial of carboplatin and paclitaxel compared with cisplatin and paclitaxel in patients with optimally resected stage III ovarian cancer: a gynecologic oncology group study. *J Clin Oncol* 21:3194–3200
6. Shih KK, Chi DS (2010) Maximal cytoreductive effort in epithelial ovarian cancer surgery. *J Gynecol Oncol* 21:75–80
7. Chi DS, Eisenhauer EL, Lang J et al (2006) What is the optimal goal of primary cytoreductive surgery for bulky stage IIIC epithelial ovarian carcinoma (EOC)? *Gynecol Oncol* 103:559–564
8. Eisenkop SM, Friedman RL, Wang HJ (1998) Complete cytoreductive surgery is feasible and maximizes survival in patients with advanced epithelial ovarian cancer: a prospective study. *Gynecol Oncol* 69(2):103–108
9. Bristow RE, Tomacruz RS, Armstrong DK (2002) Survival effect of maximal cytoreductive surgery for advanced ovarian carcinoma during the platinum era: a meta-analysis. *J Clin Oncol* 20:1248–1259
10. Aletti GD, Dowdy SC, Gostout BS et al (2006) Aggressive surgical effort and improved survival in advanced-stage ovarian cancer. *Obstet Gynecol* 107:77–85
11. Salani R, Zahurak ML, Santillan A (2007) Survival impact of multiple bowel resections in patients undergoing primary cytoreductive surgery for advanced ovarian cancer: a case-control study. *Gynecol Oncol* 107(3):495–499

12. Winter WE, Maxwell GL, Tian C et al (2008) Tumor residual after surgical cytoreduction in prediction of clinical outcome in stage IV epithelial ovarian cancer: a Gynecologic Oncology Group Study. *J Clin Oncol* 26(1):83–89
13. Winter WE, Maxwell GL, Tian C et al (2007) Prognostic factors for stage III epithelial ovarian cancer: a Gynecologic Oncology Group Study. *J Clin Oncol* 25:3621–3627
14. Bristow RE, Duska LR, Lambrou NC et al (2000) A model for predicting surgical outcome in patients with advanced ovarian carcinoma using computed tomography. *Cancer* 89:1532–1540
15. Dowdy SC, Mullany SA, Brandt KR et al (2004) The utility of computed tomography scans in predicting suboptimal cytoreductive surgery in women with advanced ovarian carcinoma. *Cancer* 101:346–352
16. Qayyum A, Coakley FV, Westphalen AC (2005) Role of CT and MR imaging in predicting optimal cytoreduction of newly diagnosed primary epithelial ovarian cancer. *Gynecol Oncol* 96:301–306
17. Suidan RS, Ramirez PT, Sarasohn DM (2014) A multicenter prospective trial evaluating the ability of preoperative computed tomography scan and serum CA-125 to predict suboptimal cytoreduction at primary debulking surgery for advanced ovarian, fallopian tube, and peritoneal cancer. *Gynecol Oncol* 134(3):455–461
18. Fagotti A, Ferrandina G, Fanfani F et al (2006) A laparoscopy-based score to predict surgical outcome in patients with advanced ovarian carcinoma: a pilot study. *Ann Surg Oncol* 13(8):1156–1161
19. Kang S, Kim T-J, Nam B-H et al (2010) Preoperative serum CA-125 levels and risk of suboptimal cytoreduction in ovarian cancer: a meta-analysis. *J Surg Oncol* 101:13–17
20. Tempany CM, Zou KH, Silverman SG et al (2000) Staging of advanced ovarian cancer: comparison of imaging modalities—report from the Radiological Diagnostic Oncology Group. *Radiology* 215:761–767
21. Axtell AE, Lee MH, Bristow RE et al (2007) Multi-institutional reciprocal validation study of computed tomography predictors of suboptimal primary cytoreduction in patients with advanced ovarian cancer. *J Clin Oncol* 25(4):384–389
22. Gerner MG, Ravid M et al (2009) A multicenter validation of computerized tomography models as predictors of non-optimal primary cytoreduction of advanced epithelial ovarian cancer. *EJSO* 35:1109–1112
23. Meyers MA (1973) Distribution of intra-abdominal malignant seeding: dependency on dynamics of flow of ascitic fluid. *Am J Roentgenol Radium Ther Nucl Med* 119:198–206
24. Brockbank EC, Ind TE, Barton DP et al (2004) Preoperative predictors of suboptimal primary surgical cytoreduction in women with clinical evidence of advanced primary epithelial ovarian cancer. *Int J Gynecol Cancer* 14(1):42–50
25. Goff BA, Mandel LS, Drescher CW et al (2007) Development of an ovarian cancer symptom index: possibilities for earlier detection. *Cancer* 109(2):221–227
26. Aletti GD, Gostout BS, Podratz KC et al (2006) Ovarian cancer surgical resectability: relative impact of disease, patient status, and surgeon. *Gynecol Oncol* 100:33–37
27. Ferrandina G, Sallustio G, Fagotti A et al (2009) Role of CT scan-based and clinical evaluation in the preoperative prediction of optimal cytoreduction in advanced ovarian cancer: a prospective trial. *Br J Cancer* 101:1066–1073
28. Chandrashekhara SH, Thulkar S, Srivastava DN et al (2011) Preoperative evaluation of peritoneal deposits using multidetector computed tomography in ovarian cancer. *Br J Radiol* 84:38–43
29. Ur Metser, Colin Jones, Lindsay M. Jacks et al. (2011). Identification and quantification of peritoneal metastases in patients with ovarian cancer with multidetector computed tomography: correlation with surgery and surgical outcome. *Int J Gynecol Cancer*;21: 1391–1398
30. Buy JN, Moss AA, Ghossain MA et al (1988) Peritoneal implants from ovarian tumors: CT findings. *Radiology* 169(3):691–694
31. Coakley FV, Choi PH, Gougoutas CA et al (2002) Peritoneal metastases: detection with spiral CT in patients with ovarian cancer. *Radiology* 223:495–499
32. Vergote I, Trope CG, Amant F et al (2010) Neoadjuvant chemotherapy or primary surgery in stage IIIC or IV ovarian cancer. *N Engl J Med* 363(10):943–953