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Research article

Diffusion-weighted magnetic resonance imaging in peritoneal carcinomatosis from suspected ovarian cancer: Diagnostic performance in correlation with surgical findings

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A B S T R A C T

Purpose: Ovarian cancer (OC) is the commonest cause of death by gynaecological cancer in developed countries.

Peritoneal carcinomatosis (PC) complete debulking without residual disease of > 1 cm is the best prognostic predictor in advanced OC.

PC is assessed with Computed tomography (CT). CT accuracy and cytoreduction success predictive ability are limited. PET/CT is not an imaging standard for PC.

PC shows high signal foci in Diffusion-weighted magnetic resonance imaging (DWI MRI).

We assessed the diagnostic performance (DP) and tumour burden correlation of Whole body DWI with background suppression MRI (WB-DWIBS/MRI) in PC of suspected OC using the Peritoneal Cancer Index (PCI), referring to cytoreduction surgery as the standard reference.

Method: Fifty patients with suspicion of disseminated OC underwent cytoreduction and WB-DWIBS/MRI. The PCI scores tumour burden (0–3) in 13 anatomical regions (global range of 0–39). Two radiologists (Rad1/Rad2) assessed the PCI preoperatively and with surgical findings.

We evaluated regional and global DP, the interobserver agreement (Cohen´s kappa coefficient), statistical differences (McNemar test) and tumour burden (Pearson's test).

Results: 72% (36/50) were epithelial OC and 78% (39/50) achieved complete cytoreduction. Global-PCI correlation was 0.762 (Rad1) with DP: Sensitivity 0.84, specificity 0.89, accuracy 0.89, and kappa 0.41.

Average global-PCI was 7. The pelvis and right hypochondrium showed the highest positive rate and DP, while the intestinal regions presented the lowest. Previous studies reported higher sensitivity than CT or PET/CT, although only a few used the PCI.

Conclusions: WB-DWIBS/MRI is reliable to depict, quantify and to predict complete cytoreductive surgery in OC PC.

1. Introduction

Ovarian cancer (OC) is the primary cause of death by gynaecological cancer in developed countries, with an annual incidence of 3412 and a 5-year prevalence in the general population of 7939 for 2017 in Spain, similar to other industrialized countries [1,2]. The most common OC histology is epithelial type, and up to 65% of patients are diagnosed at stages III and IV with peritoneal carcinomatosis (PC) and nodal dissemination, with high mortality [2,3].

The treatment of choice for OC is primary surgical cytoreduction followed by platinum-based adjuvant chemotherapy [4]. If there are no criteria against abdominal resection [5], achieving complete surgical debulking without residual disease > 1 cm (R0) is the best prognostic predictor in advanced OC [5,6].Occasionally, if primary surgery cannot

Abbreviations: OC, ovarian cancer; PC, peritoneal carcinomatosis; PCI, peritoneal cancer index; CT, computed tomography; PET/CT, positron emission tomography CT with 18-fluorodeoxyglucose; HIPEC, hyperthermic intraperitoneal chemoperfusion; DWI, diffusion-weighted imaging; WB-DWIBS/MRI, whole body DWI with background suppression MRI; DP, diagnostic performance

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be performed initially [5], interval surgery after three cycles of neoadjuvant chemotherapy may be considered. Secondary cytoreduction is performed after recurrence if there is an option for R0 debulking.

Preoperative detection of irresectable disease is crucial for the selection of surgical candidates, and the detection and location of peritoneal seeding in OC is useful in the planning of accurate surgery. Laparoscopy has been proposed as a preoperative approach to tumour evaluation using the Fagotti score [7]. This system assesses eight peritoneal structures and assigns a score of 0–2. If global scoring is ≥8, then the predictive positive value (PPV) of a suboptimal surgical result is 100%. However, laparoscopy is an invasive technique, and it cannot evaluate the retroperitoneum nor the tumour posterior to the gastrosplenic ligament and in the lesser sac [8].

The peritoneal cancer index (PCI) [9] was described for PC quantification in surgical cytoreduction and hyperthermic intraperitoneal chemoperfusion (HIPEC). It is a region-wise scoring system that assesses 13 anatomic regions, each with a range of 0–3, and considers the largest lesion in each region according to the following categories: no tumour, LS0; up to 0.5 cm, LS 1; up to 5 cm, LS 2; and more than5 cm or confluent, LS 3 (Fig. 1). The PCI is calculated through the sum of all regional scores in each patient, with a total burden range of 0–39. It is used in digestive carcinomatosis candidates for cytoreduction and HIPEC, but not as often in ovarian carcinomatosis given that the only accepted prognostic factor is complete (R0) debulking, whereas HIPEC is still under discussion for advanced OC [10].

Different imaging techniques are used in preoperative PC assessment and describe several dissemination patterns [11,12], although no imaging tool is capable of predicting the success of a R0 resection. Computed tomography (CT) is the elective technique for abdominal imaging and, when using a dedicated protocol, CT correlates well with the surgical PCI [13]. CT is recommended for staging and follow up in gynaecological malignancies by the American College of Radiology (ACR) and National Comprehensive Cancer Network (NCCN) guidelines. The accuracy of CT for PC in OC and its capability for predicting the success of cytoreductive surgery is limited, although when evaluated with CA-125 levels it may predict prognosis [14,15]. Positron emission tomography CT with 18-fluorodeoxyglucose (PET/CT) can be considered for systemic evaluation of gynaecological malignancies, although it is not yet established as a reference standard for PC depiction [16]. Conventional MRI is useful in peritoneal carcinomatosis [17], however its diagnostic performance (DP) is inferior to PET/CT [18,19] and similar to CT [20]. Diffusion-weighted imaging (DWI) is obtained using high-energy short-time MR radiofrequency pulses, where the *b* value expresses the strength of potentiation in diffusion. Using high *b* values (*b* max≥ 1000), DWI provides a very high signal intensity of structures with water movement restriction and almost no signal from other anatomical structures. Dynamic contrast-enhanced imaging and DWI improve the capability of tumour pelvic recurrence characterisation [21], and the addition of high *b* DWI to routine MRI raises the DP for peritoneal metastases [22–25]. Finally, whole body DWI with background suppression MRI (WB-DWIBS/MRI) combines high *b* DWI with conventional imaging of the entire body for anatomical referencing and characterisation of findings [26].

This study aimed to assess the DP and tumour burden correlation of WB-DWIBS/MRI in PC from suspected OC using the PCI, referring to cytoreduction surgery as the standard reference.

2. Material and methods

2.1. Study design

This is an observational, prospective, single-institution, non-comparative, DP study of WBMRI/DWIBS versus the pathologically-proven surgical standard of reference. Institutional review board approval was obtained, and all patients signed written informed consent.

2.2. Study population

Inclusion criteria included suspected diagnosis of a primary or recurrent ovarian carcinoma according to raised CA-125 levels and imaging findings. Exclusion criteria were claustrophobia, known renal impairment (creatinine > 1.5 mg/dl or glomerular filtration rate < 60 ml/min/1.73m^2), contraindications to hyoscine butyl-bromide (allergies, glaucoma, history of bowel obstruction, or urinary retention), non-operable patients, and non-resectable disease [5,8]. Patients considered for interval debulking surgery were disregarded for this study.

From June 2014 to January 2017, 217 consecutive patients presented at our institution and were evaluated at interdisciplinary

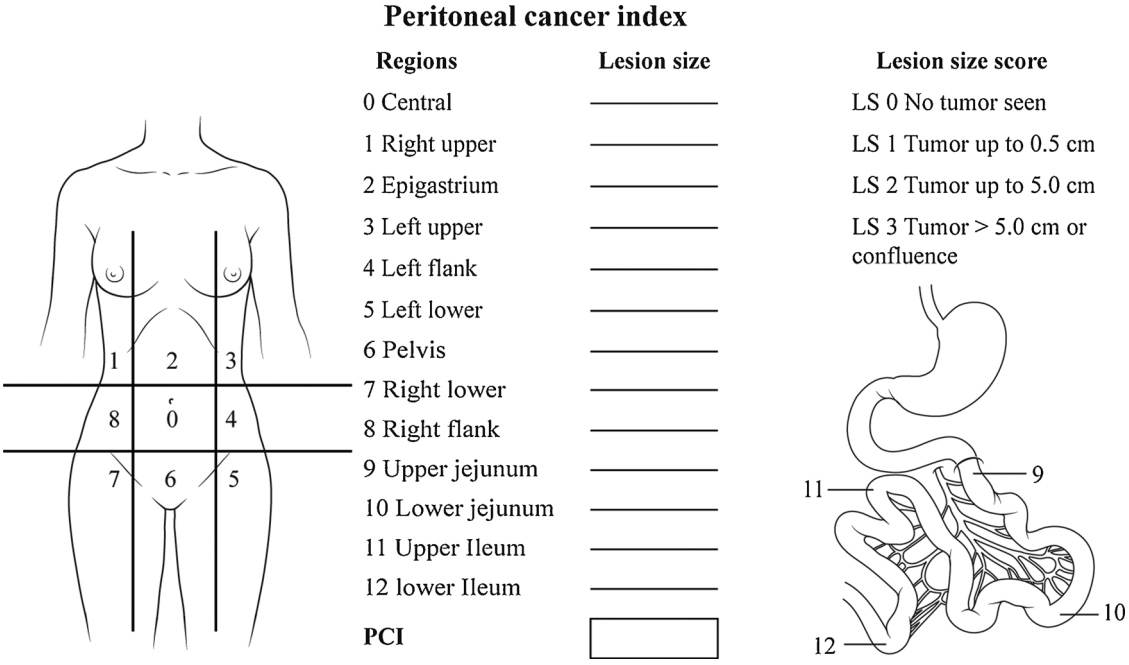

Fig. 1. Peritoneal cancer index (PCI) diagram showing the 13 evaluated regions and the possible tumour burden (0–3) according to implant size.

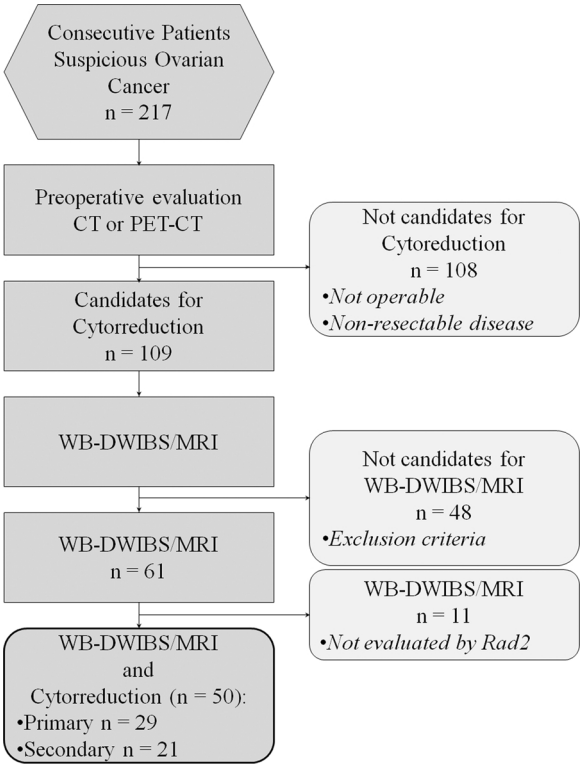

Fig. 2. Flowchart showing the sample selection criteria for the study.

meetings. Of these, 108 were considered for initial chemotherapy and 109 were candidates for cytoreduction and were offered a WBMRI/DWIBS examination. Sixty-one patients met all the inclusion criteria (Fig. 2); of these,11 patients were evaluated by Rad1 and underwent surgery with no evaluation by Rad2, thus they were excluded from the study to avoid any information bias. In total, 50 patients were finally considered for the study. Any finding on WBMRI/DWIBS beyond the surgical field that would preclude surgery was studied with other techniques and biopsied when possible.

2.3. Imaging protocol

Patients drank 1 L of pure pineapple juice 2 h before imaging as a negative oral contrast agent. We injected 20 mg of hyoscine butylbromide diluted in 100 ml saline solution; 50 ml was administered at the beginning of the examination and the other 50 ml before the DWIBS sequence. Intravenous contrast gadobutrol at 1 mmol/ml (0.2 ml/kg weight) was given at an injection rate of 2 ml/s (MEDRAD® Spectris Solaris EP Injection System, Bayer AGLeverkusen, Germany).

Imaging was performed on a 1.5 T system (Ingenia, Philips Healthcare, Best, Netherlands) (Table 1) with head/neck and two body phased-array coils for anatomical coverage from the head to the mid thighs [25,26].

Coronal and axial single-shot T2-weighted turbo spin echo (T2TSE) and volumetric 3DT1-weighted fat sat gradient-echo (3DT1GE) for anatomical evaluation and DWIBS imaging (*b*-values: 0 and 1000s/mm^2) were obtained in the coronal plane.

In a dedicated MR workstation (IntelliSpace Portal Version 606.20039, Philips Medical Systems Nederland B.V.), we obtained reformatted maximum intensity projection (MIP) images in the axial and sagittal planes, colour-derived maps using T2TSE and 3DT1GE as a reference layer, and MIP-DWIBS as a colour functional overlay (alpha blending, 50%).

2.4. Imaging analysis

Two radiologists (Rad1 and Rad2, who had 10 and 5 years of experience in abdominal imaging, respectively) read the same 50 examinations, and were both blinded to medical history and the other radiologist's findings. They used the PCI (Fig. 1) [9] to assess regional DP in the 50 cases.

CT or PET/CT were not evaluated given that they were performed at external institutions with wide technical variations, therefore comparisons were not possible. We considered DWIBS primarily for tumour detection and the findings were correlated with T2TSE and 3DT1GE sequences for anatomical location.

A positive finding was considered for any size of nodular, plaque, or linear intrabdominal high signal foci on DW and was measured (0–3) for every region (13) in each patient, based on the PCI. If a nodule was detected in conventional images but showed no signal in DWI, it was

Table 1
Sequence protocol of WB-DWIBS/MRI. DWIBS, diffusion-weighted imaging with background suppression; 3DT1GE, 3D volumetric gradient echo T1; THRIVE, T1-weighted high resolution isotropic volume examination; SPAIR,spectrally adiabatic inversion recovery; mDIXON, multi-echo 2-point DIXON.

Primary Acquisition	DWIBS	T2TSE	3DT1GE	
Orientation:	Coronal	Axial, coronal	Axial, coronal	Axial
Coverage:	Head – mid thigh	Head – mid thigh	Abdomen – pelvis	Chest
Repetition time (TR):	4736	1000	5.9	3.7
Echo Time (TE):	78	80	1.8	1.76
Flip angle			15°	10°
Number of signal Average (NSA):	4	1	1	1
FOV (RL × AP × CC) (mm):	450 × 230 × 300	498 × 230 × 400	400 × 352 × 230	400 × 359 × 230
Station Number:	3	4	2	1
Slice Thickness (ST) (mm):	6	6	4	4
Slice Number (SN) Coronal:	40	35	120	
Slice Number (SN) Axial:		140	120	115
Slice Spacing (mm):	0	1	0	0
Acquired voxel size (RL × AP × CC):	3.5 × 3.5	2 × 1.6	2 × 2 × 4	2.56 × 2.56 × 4
Reconstructed voxel size :	1.76	1.04	1 × 1 × 2	1 × 1 × 2
Respiration	Free	Triggered	Breathold	Breathold
Parallel imaging factor (SENSE)	4	2	2 × 1.3	2 × 1.3
Fat suppression			SPAIR (mDIXON)	SPAIR (eTHRIVE)
b values (s/mm^2)	0-1000			
Derived Images		**Color fusion (DW overlay)**	**Color fusion (DW overlay)**	
	MIP Axial, sagital 3D Volumetric Coronal	Coronal	Axial, coronal	

Table 2
Clinical characteristics and outcome in included patients.

Age *(years)	mean, (sd)	56.00	(12.69)
Time to surgery (days)	median, (range)	12	(37)
CA-125 prior surgery (U/ml)	Median,(range)	167.5	(11,760.8)
Primary site		Total (n = 50)	
	Ovary	38	
	Fallopian tube	1	
	Uterus	2	
	Cervix	3	
	Other non-malignant Gynecologic	3	
	Other malignant non-Gynecologic	3	
Disease stage	**FIGO**	Total (n = 50)	
	IA	8	
	IB1	1	
	IC1	1	
	IIA	1	
	IIB	1	
	IIIA1	1	
	IIIC	9	
	IV	2	
	N/A	5	
	Recurrent	21	
Histology		Total (n = 50)	
	Serous adenocarcinoma	28	
	Clear cell	4	
	Mixed Müllerian Malignant Tumor (MMMT)	3	
	Serous cystadenoma	2	
	Endometriosis	2	
	Borderline Tumor	2	
	Endocervical Adenocarcinoma	1	
	Breast Adenocarcinoma	1	
	Biliary adenocarcinoma	1	
	Endometrioid Adenocarcinoma	2	
	Adenosarcoma	1	
	Leiomyoma	1	
	Gastro Intestinal Stromal Tumor (GIST)	1	
	Borderline Mucinous Tumor	1	
Surgical outcome		Total (n = 50)	
	Microscopic (Complete)	39	
	Macroscopic < 1 cm (Optimal)	7	
	Macroscopic > 1 cm (Suboptimal)	4	

considered positive and was documented using the PCI.

Peritoneal surface contrast enhancement, ascites, or adhesions were not considered as peritoneal tumour. We did not evaluate the apparent diffusion coefficient (ADC) given the small size of some implants.

2.5. Standard of reference

OC treatment-naïve patients with indications for surgical resection were considered for primary cytoreduction, and those who had prior surgery were considered for non-primary cytoreduction.

Operability was considered according to clinical status and anatomical resectability criteria that were evaluated with the initial imaging techniques. PCI calculated prior to surgery was not considered for the surgical indication.

All the patients were operated upon by the same gynaecological surgeon and general surgeon. The same two pathologists evaluated all samples. Each of the pathologists and surgeons had more than 15 years of experience each in gynaecological oncology.

Regions were assessed during surgery according to the PCI system and specimens were labelled for subsequent pathological confirmation. Any finding on WBMRI/DWIBS beyond the surgical field that would preclude surgery was studied with other techniques and biopsied whenever possible.

2.6. Statistical analysis

SPSS v21.0 software (IBM) was used with *P*-values of < 0.05 indicating statistical significance. WBMRI/DWIBS findings were compared with surgery to obtain the sensitivity, specificity, positive predictive value (PPV), negative predictive value, and accuracy. Statistical differences between both techniques were calculated with the two-tailed McNemar test and Bonferroni correction was used to avoid biases.

Cohen'skappa coefficient was used to evaluate interobserver agreement ($\kappa < 0.2$, slight; < 0.4, fair; < 0.6, moderate; < 0.8, substantial; > 0.8 perfect). Surgical and preoperative global PCI was assessed with Pearson's correlation coefficient test.

3. Results

3.1. Clinical results

A total of 50 patients were selected for this study. Peritoneal seeding in 13 PCI regions was pathologically confirmed after surgery (Fig. 1). Table 2 shows the clinical outcome. Surgery was delayed in some patients due to acute comorbidities (acute infections, renal impairment and others).

Almost all the patients (94%, 47/50) presented with primary gynaecological disease; 88% (44/50) were primary gynaecological malignancies and 76% (38/50) were of ovarian origin, while the histology was epithelial type in 72% (36/50).

3.2. Imaging results

3.2.1. Global evaluation

Fig. 3 presents the frequency of disease detected in each region and Table 3 details the DP of WBMRI/DWIBS as assessed by Rad1 and Rad2.

The global average surgical PCI was 7.42 ± 5.675 and 7.08 ± 5.865 for Rad1 and for Rad2, respectively. The tumour burden, as assessed by Pearson's correlation coefficient, was 0.762 ($p < 0.001$) for Rad1 and 0.642 ($p < 0.001$) for Rad2 (Fig. 4).

Overall positive scoring (score values 1–3) for surgical findings, Rad1, and Rad2 were 28.46%, 30.77%, and 24.15%, respectively (Fig. 5).

We also explored the distribution of the total PCI for both observers and surgery (Fig. 6) based on cytoreduction results, and we found that lower initial tumour burden was followed by a higher frequency of complete cytoreduction ($p < 0.05$).

Interobserver agreement was globally fair to moderate, although it was moderate to substantial in six out of 13 regions evaluated.

3.2.2. Regional evaluation

The pelvis presented the highest number of positives for both observers and surgery with high sensitivity but moderate specificity. The central region had the second highest positive rate, with moderate sensitivity and high specificity for both observers.

The bowel loops showed a low detection rate, although they presented a good diagnostic performance.

Accuracy was over 0.86 in all regions for Rad1 and above 0.8 in 6/13 regions for Rad2, and global accuracy was 0.89 and 0.8, respectively.

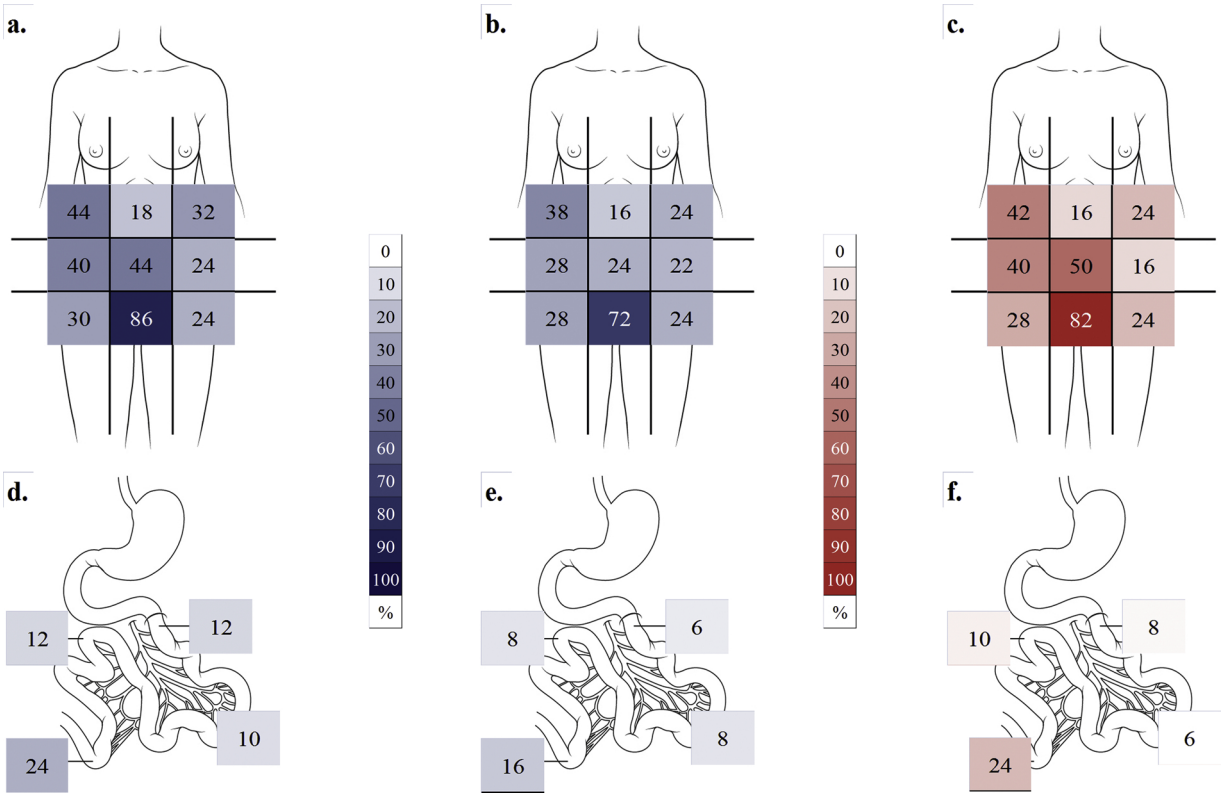

Fig. 3. Percentage of positives detected in the different peritoneal regions using the PCI system, as evaluated by observers Rad1 (a, d) and Rad2 (b, e) using WB-DWIBS/MRI compared with surgery (c, f).

Table 3
Global and regional DP of WB-DWIBS/MRI for both observers (Rad1 and Rad2) and surgery.

Peritoneal cavity	Observer	TP	TN	FP	FN	Sensitivity	Specificity	PPV	NPV	Accuracy	Kappa
0 Central	Rad1	20	23	2	5	0.8	0.92	0.91	0.82	0.86	0.41
	Rad2	11	24	1	14	0.44	0.96	0.92	0.63	0.7	
1 Right upper	Rad1	18	25	4	3	0.86	0.86	0.82	0.89	0.86	0.63
	Rad2	14	24	5	7	0.67	0.83	0.74	0.77	0.76	
2 Epigastrum	Rad1	6	39	3	2	0.75	0.93	0.67	0.95	0.9	0.22
	Rad2	2	36	6	6	0.25	0.86	0.25	0.86	0.76	
3 Letf upper	Rad1	11	33	5	1	0.92	0.87	0.69	0.97	0.88	0.8
	Rad2	9	35	3	3	0.75	0.92	0.75	0.92	0.88	
4 Left flank	Rad1	7	37	5	1	0.88	0.88	0.58	0.97	0.88	0.61
	Rad2	5	36	6	3	0.63	0.86	0.45	0.92	0.82	
5 Left lower	Rad1	6	32	6	6	0.5	0.84	0.5	0.84	0.76	0.34
	Rad2	4	30	8	8	0.33	0.79	0.33	0.79	0.68	
6 Pelvis	Rad1	40	6	3	1	0.98	0.67	0.93	0.86	0.92	0.51
	Rad2	32	5	4	9	0.78	0.56	0.89	0.36	0.74	
7 Right lower	Rad1	11	32	4	3	0.79	0.89	0.73	0.91	0.86	0.27
	Rad2	8	30	6	6	0.57	0.83	0.57	0.83	0.76	
8 Right flank	Rad1	17	27	3	3	0.85	0.9	0.85	0.9	0.88	0.47
	Rad2	11	27	3	9	0.55	0.9	0.79	0.75	0.76	
9 Upper jejunum	Rad1	4	44	2	0	1	0.96	0.67	1	0.96	0.4
	Rad2	2	45	1	2	0.5	0.98	0.67	0.96	0.94	
10 Lower jejunum	Rad1	3	45	2	0	1	0.96	0.6	1	0.96	0.15
	Rad2	1	44	3	2	0.33	0.94	0.25	0.96	0.9	
11 Upper Ileum	Rad1	4	43	2	1	0.8	0.96	0.67	0.98	0.94	0.12
	Rad2	2	43	2	3	0.4	0.96	0.5	0.93	0.9	
12 Lower Ileum	Rad1	9	35	3	3	0.75	0.92	0.75	0.92	0.88	0.38
	Rad2	5	35	3	7	0.42	0.92	0.63	0.83	0.8	
Summary	**Rad1**	**156**	**421**	**44**	**29**	**0.84**	**0.89**	**0.72**	**0.92**	**0.89**	**0.41**
	Rad2	**106**	**414**	**51**	**79**	**0.51**	**0.87**	**0.6**	**0.81**	**0.8**	
						$p < 0.001$	**$p = 0.151$**	**$p = 0.006$**	**$p < 0.001$**	**$p < 0.001$**	

4. Discussion

This prospective study evaluated DP and tumour burden quantification using WB-DWIBS/MRI in suspected ovarian PC, comparing the imaging PCI with the surgical PCI in patients undergoing primary or secondary cytoreduction. Patients who received interval debulking surgery after three cycles of chemotherapy were excluded from the study, given that tumour necrosis and bleeding might be a source of

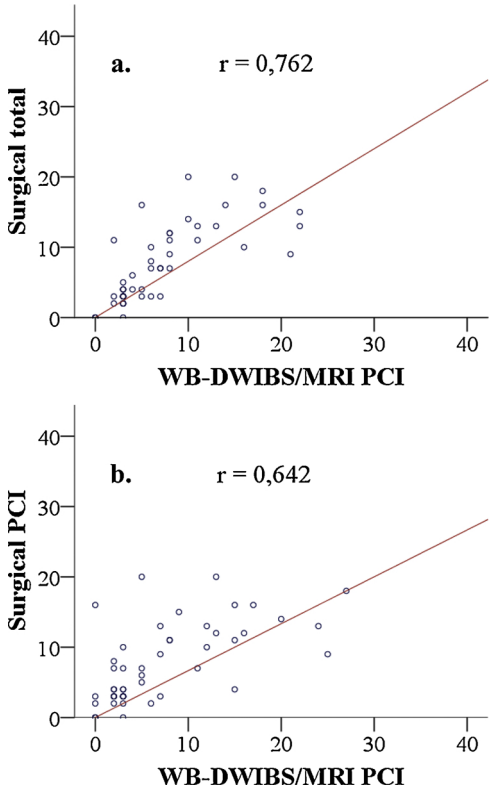

Fig. 4. Total surgical (vertical axis) and total WB-DWIBS/MRI (horizontal axis) PCI correlation for Rad1 (a) and Rad2 (b).

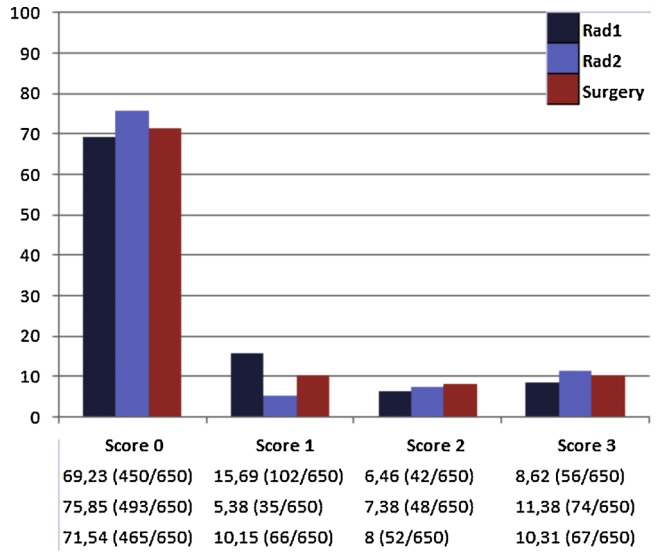

Fig. 5. Bar chart showing overall PCI score distribution of 650 (13 regions × 50 patients) observations. The results are presented in percentages and ratios in brackets.

false positives [28].

Secondary cytoreduction is a different clinical situation, in that recurrence in patients some considerable time after their primary surgery can be considered as new disease.

We adopted the PCI [9] as a reproducible means for determining PC distribution and tumour burden quantification for different imaging techniques [13,15,17,29–34] and surgical findings; others evaluated WB-MRI/DWIBS for regional ovarian carcinomatosis [25,27,35–37]in non-PCI anatomical compartments. Thus, local assessment and comparisons are difficult given the variations in classifications, although

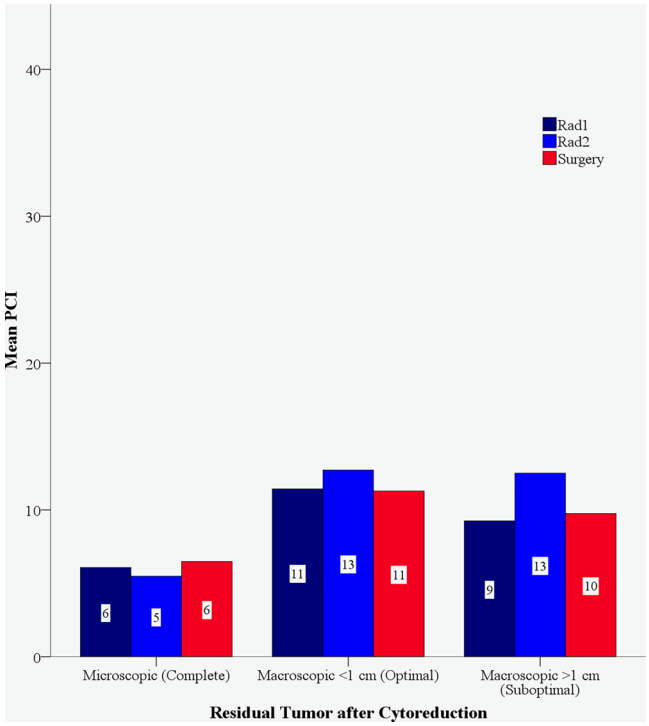

Fig. 6. Global PCI tumour burden evaluated by Rad1, Rad2, and surgery according to cytoreduction results.

global evaluation can be useful.

In the current study, global tumour burden was low (average PCI, 7) and most of the regions showed no peritoneal implants because many of the patients with high tumour burden did not fulfil the operability or resectability criteria, and therefore were not eligible for this study.

We found a significant correlation between the peritoneal tumour burden of MRI compared with surgery that was better than that reported for PET/CT or CT [16].

The pelvis followed by right hypochondrium showed the highest positive rate and diagnostic performance. The first because it is the site of the primary tumour and peritoneal implant deposits due to the effect of gravity, and the second because of the high contrast of the tumour with the liver surface (Fig. 7), whose signal is almost null in DWIBS compared with the lack of density differences in CT or PET/CT.

The intestinal regions presented the lowest positive rate because massive infiltration may preclude surgical resection if it indicates multiple anastomosis. The central zone showed a variable positive rate, partly because mesentery root infiltration may also contraindicate surgery and because omental infiltration is difficult to assign in one of these compartments. Moreover, assignation of a lesion to one or another compartment was sometimes challenging.

WB-DWIBS/MRI global and regional accuracies were statistically significant with good values, although there were regional variations.

Global PCI distribution (Fig. 6) suggested that WB-DWIBS/MRI might predict the cyto reduction result, with higher residual tumour when a higher PCI was calculated.

Our results are in line with previous studies (Table 4). To the best of our knowledge, only one previous study evaluated ovarian carcinomatosis with WB-DWIBS/MRI using PCI [32] with higher sensitivity when compared with CT and PET/CT; however, this was only conducted in 15 patients. Other studies assessing gynaecological cancer with DWIBS reported similar results, with a better DP than CT, although with variable designs, sample sizes, and different regional evaluation than the PCI [27,35–38,42].

Our DP in region 5 overlaps with that recently described for splenic infiltration [39] both for CT and MRI. The findings can be partially

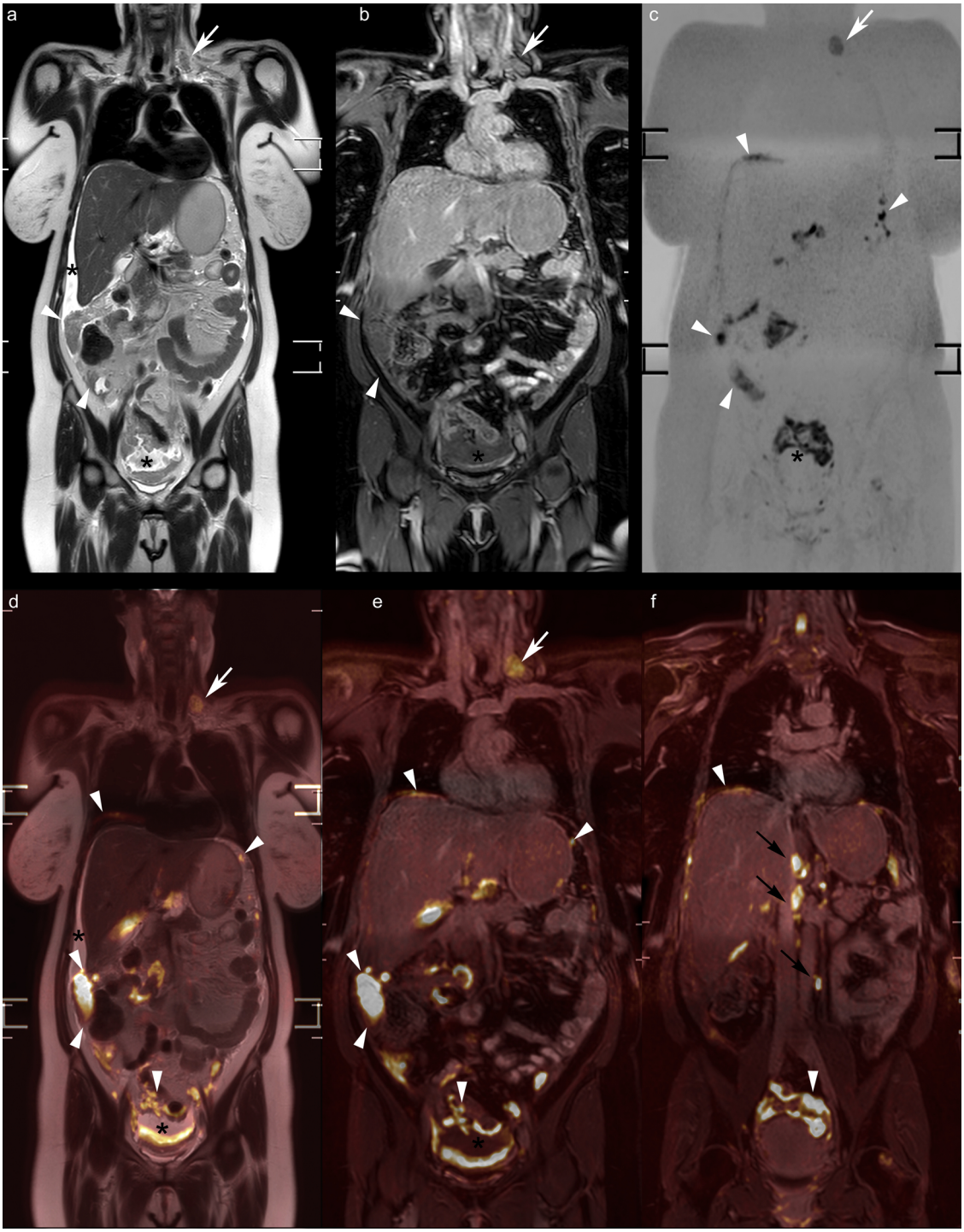

Fig. 7. Coronal native images weighted in T2TSE (a), 3DGET1 (b), and DWIBS (c) and red-scale DWIBS-fused imaging with T2 (d) and 3DGET1 (e) in the same planes as above and in the para-aortic plane (f).
Asterisks show ascites in both flanks and pelvis. Peritoneal carcinomatosis (white arrowheads) is shown in flanks, greater omentum, and subdiaphragmatic and perihepatic spaces, left hypochondrium, and pelvis surrounding ascites. Para-aortic and pericaval lymph nodes (black arrows) and supraclavicular node (white arrow) are depicted.

explained by the physiologically high DWI signal of the spleen that may make tumour detection. Miliary carcinomatosis and different critical peritoneal regions must be evaluated.

When compared with PET/CT, WB-DWIBS/MRI shows better [27,38] or at least similar [24,32] DP for PC. Some studies reported better results for PET/CT, though MR did not combine DWI sequences [18],nor were they considered in an initial meta-analysis [19]. However, a more recent study reported a better performance for WB-DWIBS/MRI than PET/CT [40].

Our regional sensitivities were very close to those previously reported [22,31,32] when evaluating WB-DWIBS/MRI with the PCI for local diagnostic performance, although with higher specificities in almost every region, probably because the use of higher *b* values (*b*1000), with the exception of the pelvis, which also showed better sensitivity.

One major limitation is that 11 patients had no OC histologies. They were included in the study given its prospective design in order to avoid

Table 4
Diagnostic performances reported for computed tomography (CT), positron emission tomography CT(PET/CT) and magnetic resonance with and without diffusion weighted sequences (DW/ No DW) in peritoneal carcinomatosis using peritoneal cancer index (PCI) or other classifications (NonPCI). Carcinomatosis are of ovarian origin (Ovarian); gynaecologic, not specifically ovarian (Gynaecologic) or a different origin (Other). Sn, sensitivity; Sp, specificity; Acc, accuracy; the values are provided in percentage. (*) are meta-analysis.

	Author	Year	Sample	Origin	Peritoneal Evaluation	MRI Technique	CT			PET/CT			MRI		
							Sn	Sp	Acc	Sn	Sp	Acc	Sn	Sp	Acc
[30]	Low	2015	22	Other	PCI	DW	55	86	63	–	–	–	95	70	88
[32]	Schmidt	2015	15	Ovarian	PCI	DW	96	92		95	96	96	98	84	93
[33]	Low	2012	33	Other	PCI	DW	88	74	84	–	–	–	–	–	–
[13]	Mazzei	2013	43	Ovarian	PCI	No MRI	100	40	93	–	–	–	–	–	–
[31]	De Iaco	2011	40	Ovarian	PCI	No MRI	–	–	–	78,9	68,4	–	–	–	–
[37]	Fehniger	2016	27	Gynaecologic	Non PCI	DW	7,7-95,2	33,3-100	–	–	–	–	0-94,1	44,4-100	–
[38]	Michielsen	2017	161	Ovarian	Non PCI	DW	66	77,3	71,3	–	–	–	94	97,7	95,7
[35]	Michielsen	2016	51	Ovarian	Non PCI	DW	0-83	92-100	–	–	–	–	52-100	33-100	–
[27]	Michielsen	2014	32	Ovarian	Non PCI	DW	65	82	75	52	85	71	91	91	91
[23]	Bozkurt	2011	19	Other	Non PCI	DW	–	–	–	–	–	–	83	94	86
[36]	Espada	2013	36	Ovarian	Non PCI	DW	–	–	–	–	–	–	50-100	83,3-100	–
[22]	Low	2009	34	Other	Non PCI	DW	–	–	–	–	–	–	71	90	81
[40]	Li (*)	2014	1067	Other	Non PCI	DW	–	–	–	89,5	97,5	–	89,7	85,4	–
[16]	Lopez-Lopez	2016	59	Ovarian	Non PCI	No MRI	35	98	–	24	93	–	–	–	–
[19]	Gu (*)	2009	–	Ovarian	Non PCI	No DW	79	84	–	91	88	–	75	78	–
[17]	Klumpp	2013	15	Other	Non PCI	No DW	–	–	–	92-93	94-96	–	87	86-92	–
[41]	Kubik-Huch	2000	19	Ovarian	Non PCI	No DW	100	67	86	100	67	86	100	100	100

any information bias. All patients fulfilled inclusion criteria. Some of them mimicked OC (leiomyomas) and other may associate OC (endometriosis). One patient with prior breast cancer presented with PC and negative bone biopsies so peritoneal biopsies were collected to exclude OC given their clinical association, and PCI was also surgically calculated.

Nevertheless, we have also calculated specific PCI and DP for those PC of pathologically proven OC origin (n = 39). We found that global interobserver agreement was slightly better (kappa 0.53) and global PCI was also slightly higher (PCI 8) with no further differences with the original sample (Supplementary Tables 1 and 2).

Another limitation is that this is a single institutional study. There may be an occult selection bias because the patients selected for the study were also candidates for cytoreduction. Therefore, the resectability itself and the areas that may contraindicate resectability might be under evaluated.

Although patients undergoing interval-debulking surgery were excluded, more than half of the study population consisted of postoperative patients, and therefore DP may have been affected. T2 shinethrough may be a source of false positive findings in DWIBS sequences, especially in dense fluids such as blood, mucin, or coagulative necrosis that maintain a hyperintense signal in high *b* DWIBS imaging [28]. However, these can be confirmed with other sequences (T2- or T1-contrast enhanced). Another major limitation is that we did not directly compare WB-DWIBS/MRI with other imaging techniques such as CT or PET/CT. This was because the patients were referred by different institutions with various initial modalities and wide variations in imaging protocols.

Nonetheless, this is a prospective study of a moderately large and very homogeneous sample population in which almost all patients were diagnosed with OC. We present a quantitative approach of our imaging findings related to surgery.

Even though it is beyond the scope of this study, WB-DWIBS/MRI can evaluate nodal and supradiaphragmatic dissemination. Given that ADC was not evaluated, further research may be needed to establish a cut-off point for DW signal intensity, similar to the standard uptake value (SUV) for PET/CT.

In conclusion, WB-DWIBS/MRI is a reliable imaging technique that is useful in preoperatively quantifying and depictingPC in OC to achieve complete cytoreductive surgery.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

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