Extended abdominopelvic MRI versus CT at the time of adnexal mass characterization for assessing radiologic peritoneal cancer index (PCI) prior to cytoreductive surgery

Basma Gadelhak[1] · Ahmed M. Tawfik[1] · Gehad A. Saleh[1] · Nihal M. Batouty[1] · Donia M. Sobh[1] · Omar Hamdy[2] · Basel Refky[2]

Abstract

Purpose To evaluate whether extending the MRI scan to include the abdomen at the time of adnexal mass characterization could replace additional CT for peritoneal cancer index (PCI) assessment.

Methods After institutional review board approval for this prospective study, 36 consecutive females with ovarian and FT malignancies were included. All patients signed an informed consent. Patients underwent preoperative CT (32 patients) and MRI (36 patients). Images were interpreted by 2 independent observers. Surgical data were available in 27 patients. Region-by-region analysis was performed for detection rates of peritoneal carcinomatosis (PC). Inter-observer agreement for each region was evaluated by kappa statistics. Radiologic PCI was calculated by CT and MRI independently and inter-observer agreement for CT and MRI as well as agreement between radiologic and surgical PCI were evaluated by weighted-kappa statistics.

Results On region-by-region analysis, the highest detection rates of PC were noted at the central abdomen and pelvis. Detection rates were higher by MRI than CT, mainly in bowel serosal surface, pelvis, and right upper abdomen regions. Inter-observer agreement of MRI was higher than CT in most regions. The median PCI by CT was 5 and 4 for the first and second observers (range 0–21 for both observers), respectively. The median PCI by MRI was 6 (range 0–23 for both observers). The inter-observer agreement of PCI was excellent by both CT and MRI ($k = 0.876$ and $k = 0.912$, respectively). The agreement between CT and surgical PCI was 0.660 and 0.590 for the first and second observers, respectively. The agreement between MRI and surgical PCI was 0.797 and 0.798 for the first and second observers, respectively.

Conclusions Extending MRI scan to include the abdomen at the time of adnexal mass characterization allows accurate estimation of PC, with better results than CT, obviating the need for dedicated CT scan of abdomen and pelvis for imaging of PC.

Keywords Peritoneal cancer index · Ovarian and fallopian tube malignancy · MRI · Diffusion weighted imaging

✉ Ahmed M. Tawfik
ahm_m_tawfik@hotmail.com; ahmedtawfik@mans.edu.eg

Basma Gadelhak
basmagadelhak@hotmail.com

Gehad A. Saleh
gehadsaleh@mans.edu.eg

Nihal M. Batouty
nihalbatouty@gmail.com

Donia M. Sobh
doniasobh2005@yahoo.com

Omar Hamdy
omarhamdy87@gmail.com

Basel Refky
dr.Basel@hotmail.com

[1] Faculty of Medicine, Department of Diagnostic and Interventional Radiology, Mansoura University, 12 El-Gomhoreya Street, Mansoura 35112, Egypt

[2] Department of Surgical Oncology, Oncology Center Mansoura University, Mansoura, Egypt

Introduction

Peritoneal carcinomatosis (PC) represents the most common pathway for the spread of ovarian cancer, and is found in 70% of patients at the time of diagnosis [1]. The management of such cancers has evolved substantially with introduction of more aggressive surgical treatments and intraperitoneal chemotherapy [2, 3].

The radiologist plays a pivotal role in accurate assessment of PC to help determine the most appropriate therapeutic strategy [3, 4]. In potential candidates for surgery, imaging helps in preoperative prediction of the likelihood of optimal cytoreduction, and identifies potentially unresectable or difficult disease sites which may require surgical technique modifications. The interpretation of peritoneal findings at preoperative imaging is challenging and requires detailed knowledge of the complex peritoneal anatomy and the direction of peritoneal fluid flow [5]. The peritoneal cancer index (PCI) provides a measurement of the volume and extent of peritoneal disease and could be assessed preoperatively by imaging [3].

Generally speaking, multidetector computed tomography (CT) is the most commonly used method to assess all PC patients of different primaries [3, 4, 6]. However, CT has its limitations, mainly insufficient soft tissue contrast and reduced sensitivity for depicting small peritoneal tumors [7, 8]. MRI provides a potent alternative to evaluate PC [9], and allows better detection of small peritoneal and serosal surface implants [10]. Combining both CT and MRI appears as an appealing option; however, this exhausts more resources and delays the diagnosis and management.

Previous studies have demonstrated the advantages of MRI for imaging of PC. However, most of these studies were retrospective and included patients with different abdominal and pelvic malignancies. Most studies were carried out in specialized centers [7, 9]. The high cost, long scanning time, and technical challenges for study optimization and the need for experience in acquisition and interpretation limit the use of MRI for imaging of peritoneal disease to specialized centers.

In ovarian and fallopian tube (FT) cancer, the role of MRI is greater than in other cancers presenting with PC (gastric, colonic, appendiceal), because MRI is the method of choice for characterization of indeterminate ovarian masses and local pelvic staging of primary ovarian and FT cancer [10, 11]. This is commonly followed at many institutions, including ours, by contrast-enhanced CT of the abdomen and pelvis to evaluate PC [12].

In this prospective study, we investigated whether extending the MRI scan at time of adnexal mass characterization to include the abdomen may obviate the need for contrast-enhanced CT of the abdomen and pelvis for PC assessment and PCI calculation in ovarian and FT cancer patients. The study outcomes include the detection rates of PC in each peritoneal region by MRI versus CT, the agreement between PCI calculated by MRI and CT with surgical findings, and the inter-observer agreement of MRI and CT.

Patient and methods

Study population

The institutional review board approved the study and all patients signed an informed consent. This prospective study was carried out on 38 consecutive patients in the period between August 2017 and July 2018, referred from a tertiary oncology center in a teaching university hospital for adnexal mass characterization, staging of ovarian/FT cancer, or preoperative assessment following neoadjuvant treatment. CT and MRI of the abdomen and pelvis were scheduled within 1 week. Surgical candidates underwent surgery within 1 week of imaging. Tumor characteristics were obtained from the medical records after pathological examination including tumor stage, grade, and histologic subtype. Two patients were excluded after the pathologic diagnosis of benign disease (TB and fibrothecoma with torsion). The final number of patients was 36.

CT technique

Post-contrast CT scan was performed in the portal and delayed phases using a multidetector CT scanner (Philips, Ingenuity, Best, Netherlands). Scan range was from the level of the diaphragm to the symphysis pubis with 128×0.6 mm-section collimation, 0.5-s gantry rotation, 120 kV, automated MA. All patients were asked to drink 1000 ml of water 20 min before the start of CT examination; fixed amount of contrast material 100 ml (Iohexol 350 mgI/ml, Omnipaque, GE health care, Ireland) was used for all patients.

MRI technique

All patients included in the study were scanned using a 1.5-T MR imaging scanner (Philips Ingenia, Best, Netherlands). Patients fasted for 4–6 h before imaging.

Imaging started at the pelvis with routine imaging sequences including T2 in the axial and sagittal planes with and without fat suppression, T1 in the axial and sagittal plane with and without fat suppression. This was followed by diffusion-weighted images using an axial single shot echo-planar sequence with b values (0, 500, 1000 s/mm^2). Dynamic post-contrast (3D gradient echo sequence with fat saturation, THRIVE, Philips) of the pelvis was performed after administration of gadoterate meglumine (Magnivest, 0.1 mmol/kg).

Imaging of the abdomen consisted of T2 and diffusion-weighted imaging in the axial plane, as well as delayed post-contrast images after 5 min of contrast administration (3D, T1W-prepared gradient echo sequence with fat saturation).

Image interpretation

CT images were reviewed first by 2 independent observers, one board-certified radiologist with 11 years of experience and special interest in abdominal imaging, and one senior resident with 5 years of experience in general imaging. After 2 months of blinding period, MRI was reviewed by the 2 readers independently. Both readers were blinded to surgical findings. The surgeon was not blinded to the CT and pelvic MRI results, and the clinical reporting was routinely done by other radiologists not sharing in the study.

The Radiologic PCI score was obtained [13]. The abdomen was divided into nine regions (R0–R8), and the small bowel into four regions (R9–R12). Each region was given a score according to largest lesion size (LS): LS-0 if no lesions, LS-1 denoting tumor deposits < 0.5 cm, LS-2 for tumor deposits 0.5–5 cm, and LS-3 if > 5 cm or confluent tumor deposit or omental cakes. The total PCI was then calculated as the sum of scores for each region. The minimum PCI was 0 and the maximum score was 39 [13]. Patients were categorized according to the PCI into low (0–9), moderate (10–19), and high burden (> 20).

Surgical procedures

Multidisciplinary team assessed the patients and decided the treatment plan according to CT and MRI findings, performance state, and comorbidities. During operation, the gynecologic oncologist examined all disease regions visually or by palpation, systematically reported the surgical findings, calculated the final surgical PCI, and checked whether optimal cytoreduction (OCR) was achieved or not.

Statistical analysis

Statistics was performed using SPSS version 21.0 (IBM). Inter-observer agreement between the 2 observers for CT and MRI peritoneal disease detection on a region-by-region basis was calculated using kappa statistics. Inter-observer agreement between the 2 observers for CT and MRI-PCI calculation and agreement between radiologic and surgical PCI were assessed by weighted-kappa measurements. Kappa agreement levels were interpreted as 0.00–0.20 negligible, 0.21–0.40 fair, 0.41–0.60 moderate, 0.61–0.80 good, and 0.81–1.00 almost perfect agreement. *P* values < 0.05 were considered significant.

Results

This study included 36 females with malignant ovarian and FT tumors. The mean age was 50.4 ± 12 years. Fifteen patients were primarily diagnosed and 21 had already received neoadjuvant chemotherapy for downstaging. All patients underwent MRI and 32 patients underwent CT at our institution. The image quality of MRI was diagnostic in all patients and in all regions.

Surgical and pathologic results

Surgical data were available in only 27 patients who underwent surgery at our institution. Optimal cytoreduction (CR) was achieved in 22 patients, and suboptimal cytoreduction in 5 patients. In patients with low surgical PCI, complete CR was achieved in 17 patients, and incomplete cytoreduction in 1 patient due to urinary bladder involvement while the patient refused urinary diversion. In patients with moderate PCI, complete CR was achieved in 4 patients, and incomplete CR in 2 patients due to porta-hepatis involvement and heavy diaphragmatic disease. In patients with high PCI, complete CR was achieved in 1 patient, and incomplete CR in 2.

The tumor histology was high-grade serous adenocarcinoma in 22 patients, mucinous adenocarcinoma in 2, endometrioid carcinoma in 2, and granulosa cell tumor in 1 patient.

CT detection rates and inter-observer agreement (region-by-region)

Table 1 shows the detection rates of peritoneal disease by CT and the agreement between the 2 observers on a region-by-region basis. The highest detection rates were noted at the central abdomen (R0) and pelvis (R6). The lowest detection rates were observed in the bowel serosal surface regions (R9–R12), as well as the right upper abdomen (R1). The inter-observer agreement varied among different regions. The lowest agreement was observed in R1, while best agreement was observed in the left and right flank regions (R4 and R8) and R12.

MRI detection rates and inter-observer agreement (region-by-region)

The highest detection rates by MRI were observed at R0 and R6, similar to CT (Table 2). However, the detection rates were higher by MRI than CT, mainly in the bowel serosal surface regions, pelvis, and right upper abdomen regions (Figs. 1, 2, 3). The inter-observer agreement was higher than CT in most regions, Table 2.

Table 1 CT detection rates and inter-observer agreement (region-by-region) $n = 32$

Region	Observer 1 positive	Observer 1 negative	Observer 2 positive	Observer 2 negative	Kappa	P value
1	5	27	8	24	0.333	0.049
2	11	21	10	22	0.929	0.000
3	11	21	9	23	0.855	0.000
4	8	24	8	24	1	0.000
5	8	24	8	24	0.667	0.000
6	18	14	16	16	0.625	0.000
7	12	20	12	20	0.867	0.000
8	13	19	13	19	1	0.000
9	1	31	0	32	–	–
0	18	14	17	15	0.811	0.000
10	4	28	2	30	0.636	0.000
11	4	28	2	30	0.636	0.000
12	3	29	3	29	1	0.000

Table 2 MRI detection rates and inter-observer agreement (region-by-region) $n = 36$

Region	Observer 1 positive	Observer 1 negative	Observer 2 positive	Observer 2 negative	Kappa	P value
1	12	24	12	24	1	0.000
2	11	25	11	25	1	0.000
3	11	25	11	25	1	0.000
4	9	27	8	28	0.923	0.000
5	10	26	11	25	0.799	0.000
6	16	20	17	19	0.832	0.000
7	13	23	13	23	0.880	0.000
8	14	22	13	23	0.941	0.000
9	2	34	1	35	0.654	0.000
0	18	18	19	17	0.833	0.000
10	4	32	4	32	1	0.000
11	6	30	4	32	0.769	0.000
12	6	30	4	32	0.769	0.000

Inter-observer agreement of radiologic PCI

Regarding the total PCI by CT, the median PCI was 5 and 4 for the first and second observers, range 0–21 for both observers, respectively. The median PCI calculated by MRI was 6, and the range was 0–23 for both readers.

The inter-observer agreement of both readers by CT and MRI was excellent (Fig. 4), with slightly higher agreement by MRI than CT, Table 3.

Radiologic PCI in comparison to surgical PCI

Both CT and MRI showed good agreement with surgical PCI, Fig. 5. However, MRI had better agreement with surgery than CT by both observers, Table 4.

PCI categories by CT and MRI in comparison to surgery

In the group with low burden (PCI 0–9), both CT and MRI correctly diagnosed 17/18, and overestimated the burden in 1 patient. In the group with moderate burden (PCI 10–19), CT correctly diagnosed 4/6, and underestimated the burden in 2 patients. MRI correctly diagnosed 5/6, and the PCI of 1 patient was underestimated. There was no difference between the 2 observers using CT and MRI in the low and moderate PCI groups.

In the group with high burden (PCI > 20), the first observer diagnosed 2/3 correctly by CT, and underestimated the burden in 1 patient. The second observer diagnosed 1/3 correctly by CT, and underestimated the burden in 2 patients. Both observers correctly diagnosed 3/3 patients as high burden using MRI;
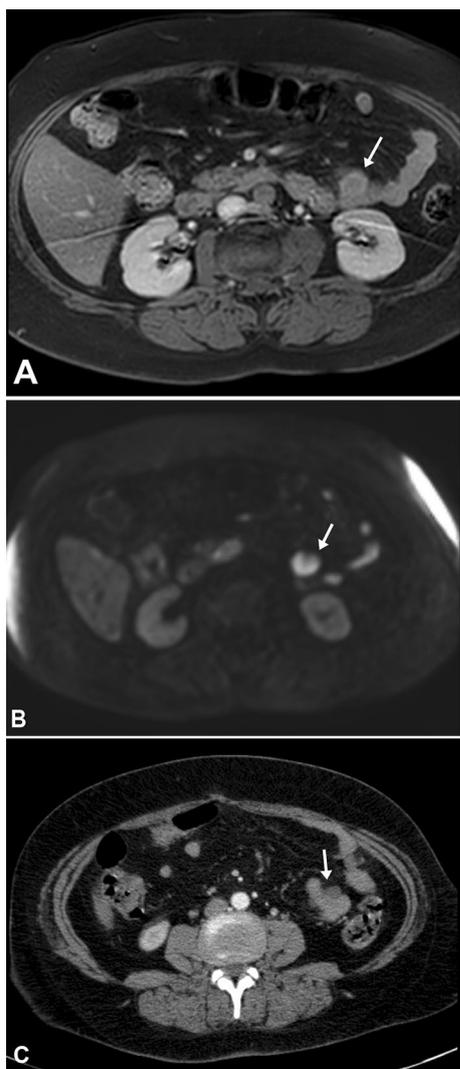
Fig. 1 A 50-year-old female with right ovarian serous adenocarcinoma. **a** Axial post-contrast T1-weighted image with fat suppression shows enhancing serosal surface implant at the distal jejunal loops, with better detection on the corresponding DW image **b** with restricted diffusion pattern (arrow). On axial post-contrast CT image **c**, this implant was missed and only seen in retrospect after MRI

however, 1 patient with moderate burden was overestimated by both observers as high burden.

Discussion

In this prospective study, we demonstrated that extending the MRI scan to include the abdomen at the time of adnexal mass characterization allows accurate estimation of peritoneal disease in ovarian and FT cancer. We used the PCI which is widely validated, provides important information about the overall disease burden, and offers better communication with surgeons than descriptive reporting styles.
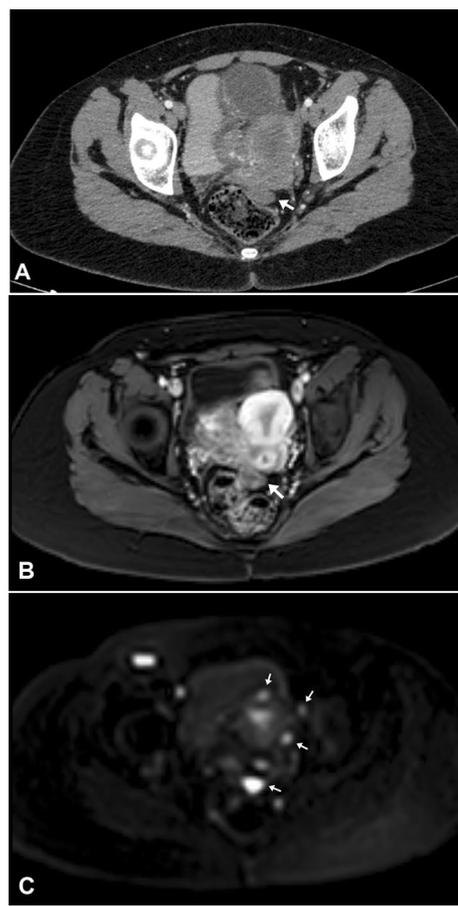

Fig. 2 A 24-year-old female with bilateral ovarian serous adenocarcinoma. **a** Axial post-contrast CT image shows part of the complex right ovarian mass and only one sizable peritoneal deposit at the Douglas pouch (arrow). Axial post-contrast T1-weighted image with fat suppression **b** shows enhanced Douglas pouch deposit (arrow). Axial DW image **c** shows more pelvic peritoneal deposits (arrows) inseparable from the uterine body with restricted diffusion pattern (Confirmed intra-operative & the patient underwent hysterectomy)

With advances in treatment options for PC, accurate imaging information have become more crucial for careful selection for candidates of cytoreduction, preventing unnecessary laparotomies in patients with findings that preclude optimal cytoreduction. Besides surgical planning, PCI also has prognostic value [3, 13, 14].

The agreement between PCI calculated by MRI and surgical PCI was good (0.8, $P < 0.00001$). The categorization of patients into low, moderate, and high PCI was correct by MRI in 24 out of 27 patients.

Comparing MRI to CT, our study demonstrated better results with MRI than CT, in agreement with few studies that directly compared MRI to CT for PCI assessment [9, 15]. On the other hand, different results were obtained by a meta-analysis on the imaging of PC, which concluded that according to the current evidence-based information, CT is still the
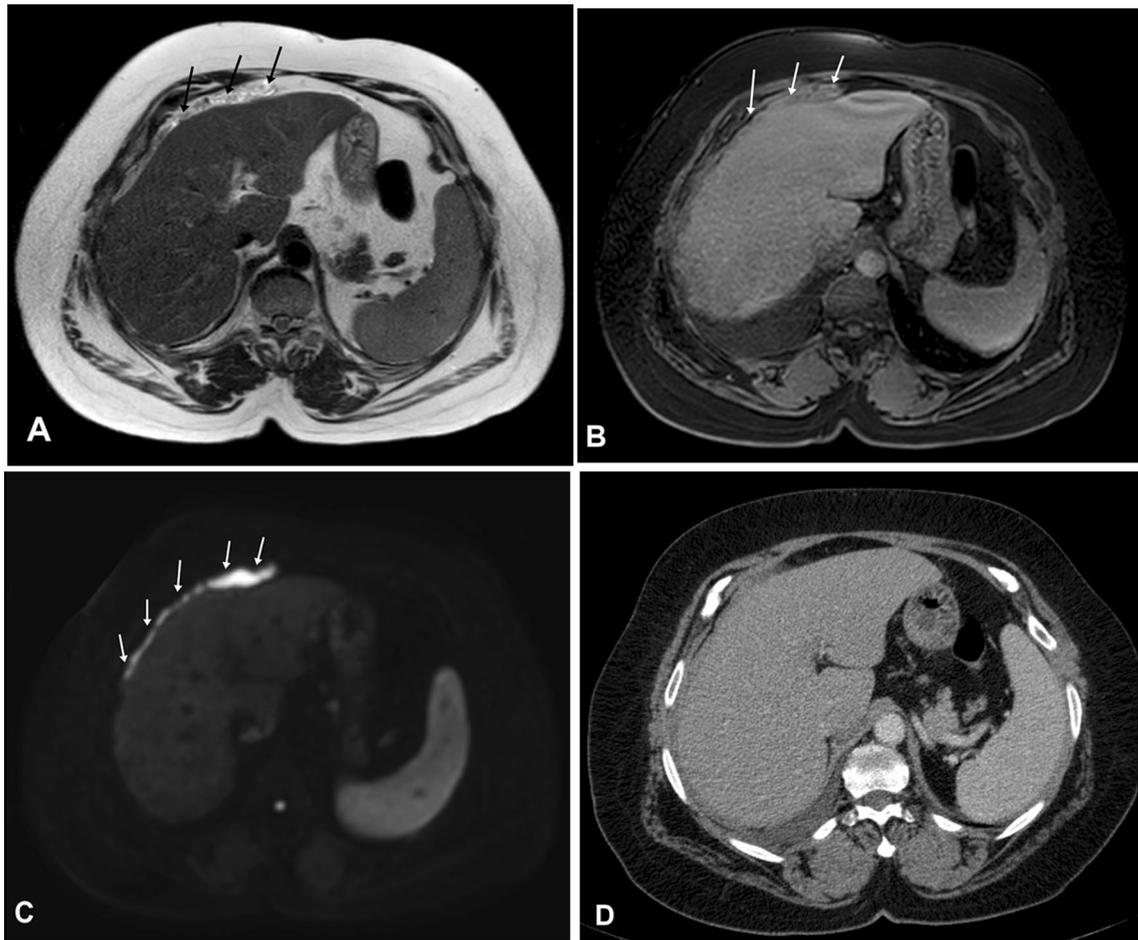
Fig. 3 A 56-year-old female with left ovarian high-grade serous adenocarcinoma. Axial T2-weighted image **a** shows right subdiaphragmatic sheet-like deposit of intermediate signal intensity (arrows). Axial post-contrast T1 image with fat suppression **b** shows the faintly enhancing deposit (arrows), with better detection of its length on the corresponding DW image **c** with restricted diffusion pattern (arrows). On axial post-contrast CT image **d**, the implant was underestimated as part of the surrounding ascites
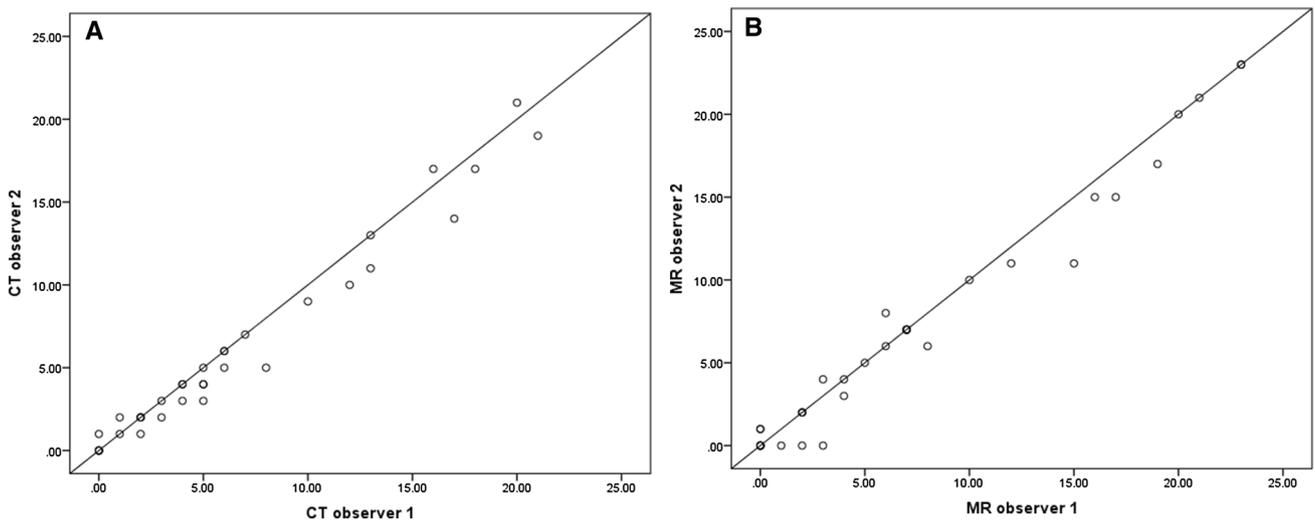

Fig. 4 **a** Scatterplot of the radiologic PCI calculated by 2 observers using CT **a** and MRI **b**. The line of perfect agreement is represented; the nearer the points to this line, the higher the agreement

Table 3 Inter-observer agreement of CT and MRI by 2 observers

	W-kappa	*P* value	CI
CT-PCI	0.876	< 0.0001	0.828–0.924
MRI-PCI	0.912	< 0.0001	0.864–0.960

Table 4 CT and MRI-PCI in comparison to surgery $n = 27$

	W-kappa	*P* value	CI
CT-PCI R1 versus surgery	0.660	< 0.0001	0.515–0.805
CT-PCI R2 versus surgery	0.590	< 0.0001	0.431–749
MRI-PCI R1 versus surgery	0.797	< 0.0001	0.696–0.898
MRI-PCI R2 versus surgery	0.798	< 0.0001	0.701–0.896

first method of choice, while MRI is the second choice due to lack of consistent data on its diagnostic yield [12].

Imaging of PC needs experience from the radiologist. Torkzad et al. reported that MRI needs more experience than CT, and according to their results, less experienced readers performed better by CT [16]. In our study, the experience of the readers had no impact on the results of MRI compared to surgery, while the more experienced observer performed slightly better by CT. The inter-observer agreement between the 2 observers for PCI calculated by MRI was slightly better than CT (0.91 vs 0.87).

As regard region-by-region analysis, MRI detected more disease than CT in almost all regions. This was more evident in the right upper abdomen region (R1), and small bowel serosal surface regions (R9–12). This is in agreement with previous studies [17–19]. The low CT agreement in R1 may be explained by the limited soft tissue contrast of CT, which causes masking of small peritoneal implants in the presence of ascites. On the other hand, peritoneal disease on the surface of the liver was mistakenly interpreted as thin rim of ascites in some of our patients. We also found much better inter-observer agreement in the same regions by MRI compared to CT. In these less discernible regions, DWI performed best because small deposits demonstrate high signal on high *b* value images against the suppressed background signal [10, 11]. In addition, the combination of delayed enhancement and fat suppression augments the

contrast between peritoneal deposits and surrounding tissue [4, 20].

This study has some limitations; first, our study population consisted of candidates for cytoreductive surgery, and therefore the study included higher percentage of low- and moderate-burden disease than high-burden disease. Second, because of the prospective nature of the study, some patients lacked surgical details or lost to follow-up. Third, we did not measure ADC values in peritoneal deposits. Nevertheless, the importance of ADC values in this setting is questionable. In a previous study that attempted ADC measurement in imaging of PC, peritoneal metastases < 1 cm were excluded because of difficulty in measuring ADC values, which hinder its clinical usage in detection of small lesions [21]. Finally, the routine use of oral and intrarectal MRI contrast for bowel opacification, together with antiperistaltic agent, was recommended by some authors [7]. This is not routinely used at our institution for primary diagnosis and staging of suspected ovarian and FT cancer, and therefore we did not use it in this study.

In conclusion, extending the MRI scan to include the abdomen at the time of primary diagnosis of suspected ovarian and FT cancer allows accurate estimation of peritoneal disease, with at least similar or even better
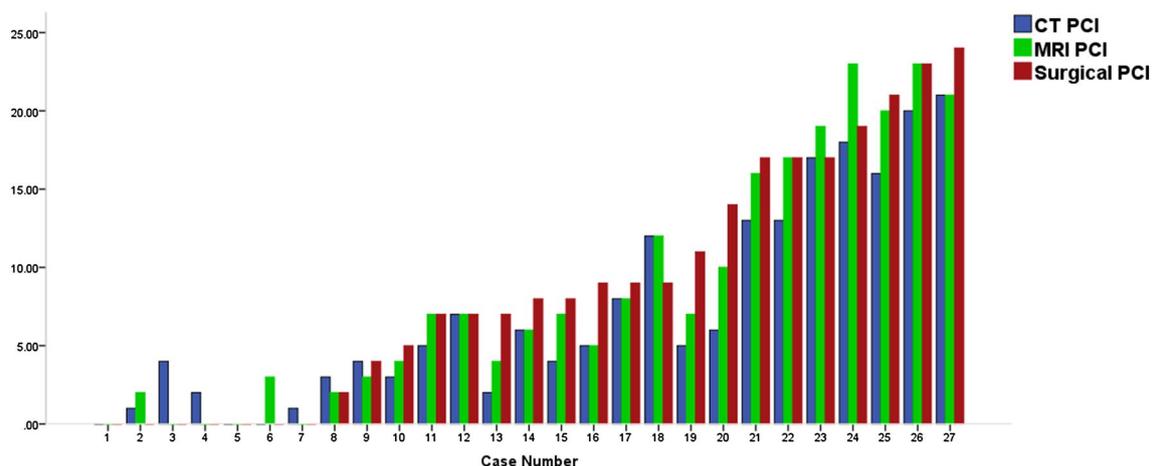
Fig. 5 Bar chart showing CT and MRI-PCI scores (calculated by the more experienced observer) compared to surgery

results than CT, obviating the need for dedicated contrast-enhanced CT scan of the abdomen and pelvis for imaging of PC.

Compliance with ethical standards

Conflict of interest The authors report no relationships that could be construed as a conflict of interest.

References

1. Rodolfino E, Devicienti E, Miccò M, et al. (2016) Diagnostic accuracy of MDCT in the evaluation of patients with peritoneal carcinomatosis from ovarian cancer: is delayed enhanced phase really effective? Eur Rev Med Pharmacol Sci. 20:4426–34.

2. Espada M, Garcia-Flores JR, Jimenez M, Alvarez-Moreno E, De Haro M, Gonzalez-Cortijo L, et al. Diffusion-weighted magnetic resonance imaging evaluation of intra-abdominal sites of implants to predict likelihood of suboptimal cytoreductive surgery in patients with ovarian carcinoma. Eur Radiol. 2013;23(9):2636–42.

3. Aherne EA, Fenlon HM, Shields CJ, Mulsow JJ, Cronin CG. What the radiologist should know about treatment of peritoneal malignancy. Am J Roentgenol. 2017;208(3):531–43.

4. Wasnik AP, Maturen KE, Kaza RK, Al-Hawary MM, Francis IR. Primary and secondary disease of the peritoneum and mesentery: review of anatomy and imaging features. Abdom Imaging. 2015;40(3):626–42.

5. Nougaret S, Addley HC, Colombo PE, Fujii S, Al Sharif SS, Tirumani SH, et al. Ovarian carcinomatosis: how the radiologist can help plan the surgical approach. Radiographics. 2012;32(6):1775–800.

6. Krishnamurthy S, Balasubramaniam R. Role of imaging in peritoneal surface malignancies. Indian J Surg Oncol. 2016;7(4):441–52.

7. Low RN, Barone RM. Combined diffusion-weighted and gadolinium-enhanced MRI can accurately predict the peritoneal cancer index preoperatively in patients being considered for cytoreductive surgical procedures. Ann Surg Oncol. 2012;19(5):1394–401.

8. Winfield JM, Priest AN, Wakefield JC, Hodgkin C, Freeman S, Orton MR, et al. Modelling DW-MRI data from primary and metastatic ovarian tumours. Eur Radiol. 2015;25(7):2033–40.

9. Dohan A, Hoeffel C, Soyer P, Jannot AS, Valette P, Thivolet A, et al. Evaluation of the peritoneal carcinomatosis index with CT and MRI. Br J Surg. 2017;104(9):1244–9.

10. Sala E, Rockall AG, Freeman SJ, Mitchell DG, Reinhold C. The added role of MR imaging in treatment stratification of patients with gynecologic malignancies: what the radiologist needs to know. Radiology. 2013;266(3):717–40.

11. Addley H, Moyle P, Freeman S. Diffusion-weighted imaging in gynaecological malignancy. Clin Radiol. 2017;72(11):981–90.

12. Laghi A, Bellini D, Rengo M, Accarpio F, Caruso D, Biacchi D, et al. Diagnostic performance of computed tomography and magnetic resonance imaging for detecting peritoneal metastases: systematic review and meta-analysis. Radiol Med. 2017;122(1):1–15.

13. Sugarbaker PH. Surgical responsibilities in the management of peritoneal carcinomatosis. J Surg Oncol. 2010;101(8):713–24.

14. Elzarkaa AA, Shaalan W, Elemam D, Mansour H, Melis M, Malik E, Soliman AA. Peritoneal cancer index as a predictor of survival in advanced stage serous epithelial ovarian cancer: a prospective study. J Gynecol Oncol 2018; 29:e47.

15. Low RN, Barone RM, Lucero J. Comparison of MRI and CT for predicting the Peritoneal Cancer Index (PCI) preoperatively in patients being considered for cytoreductive surgical procedures. Ann Surg Oncol. 2015;22(5):1708–15.

16. Torkzad MR, Casta N, Bergman A, Ahlström H, Påhlman L, Mahteme H. Comparison between MRI and CT in prediction of peritoneal carcinomatosis index (PCI) in patients undergoing cytoreductive surgery in relation to the experience of the radiologist. J Surg Oncol. 2015;111(6):746–51.

17. Low RN, Barone RM. Imaging for Peritoneal Metastases. Surg Oncol Clin N Am. 2018;27(3):425–42.

18. Fehniger J, Thomas S, Lengyel E, Liao C, Tenney M, Oto A, et al. A prospective study evaluating diffusion weighted magnetic resonance imaging (DW-MRI) in the detection of peritoneal carcinomatosis in suspected gynecologic malignancies. Gynecol Oncol. 2016;142(1):169–75.

19. Iafrate F, Ciolina M, Sammartino P, Baldassari P, Rengo M, Lucchesi P, et al. Peritoneal carcinomatosis: imaging with 64-MDCT and 3T MRI with diffusion-weighted imaging. Abdom Imaging. 2012;37(4):616–27.

20. Patel CM, Sahdev A, Reznek RH. CT, MRI and PET imaging in peritoneal malignancy. Cancer Imaging. 2011;11(1):123.

21. Onur MR, Akyol M, Poyraz AK, Kocakoc E, Ogur E. Diagnosis of peritoneal metastases with abdominal malignancies: role of ADC measurement on diffusion weighted MRI. Eurasian J Med. 2012;44(3):163.