Adnexal masses: Accuracy of detection and differentiation with multidetector computed tomography

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Abstract

Objective. The aim of our study was to evaluate the accuracy of multidetector computed tomography (MDCT) on a 16-row CT scanner in the detection and differentiation of adnexal masses.

Methods. We prospectively examined 102 consecutive women with clinically or sonographically detected adnexal masses. Preoperative CT examination was performed, including scanning of the abdomen during the portal phase, using a detector collimation of 16 × 0.75 mm and a pitch of 1.2. Multiplanar reformatted images were evaluated for the presence of an adnexal mass and differentiation between benign and malignant ones, using the surgical and pathologic results as standard of reference. CT findings used to diagnose malignancy were: diameter greater than 4 cm, presence of masses bilaterally, cystic-solid mass, necrosis in a solid lesion, cystic lesion with thick, irregular walls or septa and/or with papillary projections. Presence of ascites, peritoneal metastases and lymphadenopathy was used to confirm malignancy. Multiple logistic regression analysis of the MDCT findings was performed to determine those more predictive of malignancy.

Results. Histopathologic examination demonstrated 143 adnexal mass lesions, 96 (67%) of which were benign and 47 (33%) malignant. Multidetector CT detected 129 (90%) of the 143 adnexal masses, with an overall accuracy for the diagnosis of malignancy of 89.15%. The MDCT findings that found more predictive of malignancy were the presence of papillary projections in a cystic lesion, necrosis in solid mass and peritoneal metastases.

Conclusion. Multidetector computed tomography on a 16-row CT scanner proved accurate in the detection and characterization of adnexal masses.

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Keywords: Computed; Multidetector CT; Adnexal masses; Ovarian cancer

Introduction

The preoperative characterization of an adnexal mass is of utmost importance and often not possible, until surgery and pathologic examination are performed. Exploratory laparotomy was the treatment of choice for the diagnosis and therapy of adnexal masses until the past decade [1]. In recent years, surgical laparoscopy has been used to manage benign adnexal masses with minimal surgical morbidity [2,3]. However, surgery remains the standard approach in cases of ovarian carcinoma, including staging laparotomy and tumor debulking [1]. The main objective of imaging in the evaluation of an adnexal mass is the determination of malignancy. A reliable imaging technique to detect and characterize an adnexal mass would allow for appropriate subspecialty referral and optimal preoperative planning.
isotropic sub millimeter spatial resolution [19–21]. Multidetector computed tomography (MDCT) introduced in 1998, represents the latest development in helical CT technology. A 16-row CT scanner tomography (MDCT) improved the sensitivity of CT in the detection of peritoneal metastases [24,25].

Ultrasoundography (US) remains the primary imaging modality in the evaluation of a suspected adnexal mass [4–6], with MR imaging required in cases of sonographically indeterminate mass lesions [7–15]. Among women with adnexal masses, computed tomography (CT) has been used primarily in patients with ovarian malignancies to provide staging information that may help in preoperative planning [16–18], while its role in the detection and differentiation between benign and malignant adnexal masses was more limited. Multidetector computed tomography (MDCT) introduced in 1998, represents the latest development in helical CT technology. A 16-row CT scanner made it possible to cover substantial anatomic volumes with isotropic sub millimeter spatial resolution [19–21]. MDCT scanners enable the generation of large volumetric data sets, to allow for two- and three-dimensional reconstructed images of outstanding quality [19–21]. Multidetector CT is currently considered the imaging modality of choice for staging patients with ovarian carcinoma, determining tumor resectability and an optimised treatment planning [22,23]. Multidetector CT scanners also improved the sensitivity of CT in the detection of peritoneal metastases [24,25].

The purpose of this study was to evaluate the accuracy of multidetector computed tomography on a 16-row CT scanner in the detection and characterization of adnexal mass lesions.

Materials and methods

In this prospective study, included are 120 consecutive women referred to our department for CT examination of the abdomen, with clinically or sonographically detected adnexal mass lesions, between February 2004 and August 2007. A medical history including patient age, menstrual history, history of prior surgery, as well as a complete clinical, a full gynecologic examination and appropriate laboratory analysis, including CA-125 measurements was recorded. The study was approved by the local research ethics committee.

Six patients were followed-up clinically or sonographically, based on the imaging diagnosis (endometriomas, n=1, uterus leiomyomas, n=2 and small-sized nonneoplastic adnexal cysts, n=3), therefore had to be excluded from this study. Three patients were also excluded, because of the histologic diagnosis (gastric adenocarcinoma, n=1, primary papillary serous peritoneal carcinoma, n=2) and three more patients, because of peritoneal carcinomatosis, not proved as most probably ovarian in origin, pathologically. Six other patients were not included in our protocol, three of them, because they already had a history of ovarian cancer, two, because they were lost on follow-up, and one patient, due to normal MDCT findings. The 102 women (age range: 16–80 years, mean age: 51 years) in whom surgical confirmation (laparoscopy or laparotomy) was obtained within 4 weeks from the CT examination constitute our population study; 57 of these women (56%) were postmenopausal.

CT technique

All examinations were performed on a 16-row CT scanner with 24 mm scanning span per rotation (MX8000 IDT, Philips). Patient’s preparation included the administration of 1000 mL of water, 30 min prior to the examination. Scanning of the abdomen was initiated 70 s (portal phase) after the intravenous administration of non-ionic iodinated contrast material. A detector collimation of 16 × 0.75 mm and a pitch of 1.2 were used. The MDCT protocol used in this study is illustrated in Table 1. The scanning of the abdomen lasted 15 s on the average.

Image interpretation was performed on a workstation (MxView, Philips). The study of the axial source images was difficult, because of a large number (approximately 700–800) of noisy images. For these reasons multiplanar reformatted images (MPRs) in the transverse, coronal and sagittal planes (using the Extended Brilliance™ V.1.0.1.1. software), with slabs of 4 mm thickness, at 3 mm intervals, were obtained and used for interpretation. Three-dimensional (3D) reformatted images using the volume rendering technique and the same software, in the coronal and/or oblique planes were also performed. These images had the advantage of depicting the volume of the tumor and the extent of the disease, as seen in surgery (Fig. 1), as well as the relationship of the masses to adjacent viscera and blood vessels. The time to generate these multiplanar reformatted and 3D images was less than 1 min.

CT data analysis

The imaging features evaluated included the number of adnexal mass lesions, origin of the mass (ovarian or extraovarian), lesion size and content. Adnexal masses were characterized as entirely cystic, partly cystic-solid and cystic-solid. 3D-reconstructed image depicts a right adnexal tumor (star), infiltrating the cecum (arrow). The CT findings were confirmed on pathology.

Table 1

<table>
<thead>
<tr>
<th>MDCT protocol for the evaluation of adnexal masses</th>
</tr>
</thead>
<tbody>
<tr>
<td>16-row CT</td>
</tr>
<tr>
<td>Area</td>
</tr>
<tr>
<td>Diaphragm — symphysis pubis (craniocaudal)</td>
</tr>
<tr>
<td>Detector collimation (mm)</td>
</tr>
<tr>
<td>16 × 0.75</td>
</tr>
<tr>
<td>Pitch</td>
</tr>
<tr>
<td>1.2</td>
</tr>
<tr>
<td>Slice collimation (mm)</td>
</tr>
<tr>
<td>0.8</td>
</tr>
<tr>
<td>Reconstruction interval (mm)</td>
</tr>
<tr>
<td>0.5</td>
</tr>
<tr>
<td>kV/rotation time (s)</td>
</tr>
<tr>
<td>120/0.5</td>
</tr>
<tr>
<td>mAs/primary/mAs/secondary</td>
</tr>
<tr>
<td>130/110</td>
</tr>
<tr>
<td>Scan delay (s)</td>
</tr>
<tr>
<td>70</td>
</tr>
<tr>
<td>Flow rate</td>
</tr>
<tr>
<td>3 mL/s</td>
</tr>
<tr>
<td>Contrast material intravenously (mL)</td>
</tr>
<tr>
<td>120 (320 mg I/mL)</td>
</tr>
<tr>
<td>Contrast material per os</td>
</tr>
<tr>
<td>1000 mL water, 30 min prior</td>
</tr>
</tbody>
</table>

Fig. 1. 74-year old woman with low-grade right serous ovarian cystadenocarcinoma. 3D-reconstructed image depicts a right adnexal tumor (star), infiltrating the cecum (arrow). The CT findings were confirmed on pathology.
solid. The wall of the tumor was characterized as thick, when it was 3 mm or greater. For cystic and solid-cystic lesions, the presence and number of septa, their thickness (whether less than 3 mm, equal or greater than 3 mm), the presence of irregularity and papillary projections were recorded. Contrast material enhancement from the solid portions of the masses, whether homogeneous or heterogeneous, and the presence of necrosis within the tumor, as well as the enhancement of the wall, septa or papillary projections were also evaluated. Other CT findings recorded were the extension to the adjacent pelvic organs or pelvic sidewalls, the presence of lymph nodes (considering a minimum axial diameter of 10 mm as the upper limit of normal nodal size) [26] and the presence of ascites or peritoneal metastases.

CT features that were considered suggestive of benignity were the following: a lesion diameter of less than 4 cm, entirely cystic components, lack of internal structures, a wall thickness of less than 3 mm and absence of ascites or invasive disease such as peritoneal metastases or lymphadenopathy [27–30]. More specifically, a unilocular or multilocular tumor filled with serous fluid of homogeneous CT attenuation, not enhancing after contrast material administration, except the wall or septa, of less than 3 mm in thickness, was more compatible with the diagnosis of a serous cystadenoma (Fig. 2). A multilocular cystic mass with thin wall or septa, containing liquids of higher than water CT density (>20 HU) due to the presence of mucin, was considered to represent a mucinous cystadenoma. Similarly, an oblong, tubular, fluid-filled structure was considered compatible with the diagnosis of a dilated fallopian tube [31]. Fat attenuation within a cyst, with or without calcification in the wall was considered diagnostic of a mature cystic teratoma [32]. The presence of a smoothly circumscribed, homogeneous solid ovarian mass was also considered more compatible with a benign diagnosis and a homogeneous hyperdense mass lesion (measuring 50–70 HU), was thought to represent a benign ovarian lesion with hemorrhagic content (hemorrhagic cyst or endometrioma). Conversely, CT primary features indicative of malignancy of an adnexal mass were the following: size larger than 4 cm, presence of bilateral adnexal masses, a mass partly cystic and solid, with solid components enhancing after contrast material administration and presence of necrosis in a solid tumor (Fig. 3), [7–10,27–30]. For cystic and solid-cystic lesions, imaging characteristics and enhancement of the wall or septa were of major concern in the characterization of an adnexal mass. The presence of an irregular, thick wall or septum, of thickness more than 3 mm and/or papillary projections, which enhanced after i. v. contrast material administration, was indicative of malignancy. Ancillary findings such as, pelvic organ or pelvic sidewall invasion, ascites, peritoneal metastases (Fig. 4) and lymphadenopathy were used to confirm malignancy. A lesion was characterized as malignant when at least two primary criteria or one primary and one ancillary finding were present. In this regard, wall or septal thickening was considered less indicative of malignancy, because it has also been described in benign lesions, such as endometriomas and abscesses [29,30].

When malignancy was suspected a staging effort was made based on the International Federation of Gynecology and Obstetrics (FIGO) guidelines (Table 2). The guidelines used did not include the presence of microscopic
peritoneal metastases and all cases of ascites were considered malignant, since
the characterization of ascites, whether benign or malignant was not possible
based on imaging findings.

The CT data were evaluated by two radiologists (A. C. T. and C. T.) in
consensus, with 5 and 3 years of experience in female imaging respectively,
without the knowledge of either the clinical and laboratory data or the surgical
and histopathologic findings. MDCT findings were then correlated with the
histologic findings, which were the standard of reference. Tumors of borderline
malignancy on histology were categorized as malignant.

Statistical analysis

Accuracy, sensitivity, specificity, positive and negative predictive value were
estimated in order to evaluate the ability of MDCT to differentiate benign from
malignant adnexal masses, using the histopathologic diagnosis as the standard of
reference. Binary logistic regression analysis was conducted using histological
diagnosis as dependent variable in order to evaluate the predictive value of CT
features used to diagnose malignancy. Independent variables giving a
statistically significant association in the univariate analysis were included in
the multivariate model. Masses with a presumptive diagnosis of uterine origin,
or of a mature cystic teratoma, or of a dilated fallopian tube were excluded from
MDCT features analysis. As a result the analysis of imaging features of 92
adnexal mass lesions in 77 women was performed.

Dosimetry

The free-in-air Computed Tomography Dose index was measured on the
axis of rotation of the scanner using a pencil-shaped ion chamber (type 10 × 5
10.3 CT, by Radcal Corp., California, USA). The effective dose (ICRP, 1990)
was calculated using the ImPACT CT Patient Dosimetry Calculator (version
0.99 × 20/01/06). The software used was based on the Monte Carlo conversion
coefficients obtained by Jones and Shrimpton corresponding to the NRPB
mathematical phantom [33]. Taking into account that the tube current was
modulated across the patient’s body (Dose modulation function), the mean mAs
per rotation was recorded for ten successive patients and the mean mAs per
rotation among all patients was calculated.

Results

At surgery, 143 adnexal mass lesions were found in 102
women; of them 96 (67%) lesions were benign and 47 (33%)
were malignant at histopathology. Sixty-eight women had benign
lesions (age range: 16–80 years, mean age: 48 years), 32 had
malignant masses (age range: 22–79 years, mean age: 60 years),
and in two, both benign and malignant lesions were found to
coeexist. In 21 patients, masses were uterine in origin (leiomyo-
mas or adenomyosis in 19 patients and uterine malignancies in
two cases), in 75 patients were adnexal, and six patients had both
uterine and adnexal mass lesions. The histopathologic diagnoses
of the 143 masses are illustrated in Table 3.
MDCT detected 129 (90%) of the 143 adnexal masses. The size of the mass lesions detected ranged from 1.5 cm to 28 cm in maximal diameter (mean size: 9.3 cm). Fourteen lesions – eight benign and six malignant – were not detected. The benign lesions that were not detected were two cases of functional ovarian cysts, one case of an endometrioma and one case of a serous cystadenoma, all lesions measuring less than 0.5 cm in diameter (n=4), and one case of two benign cystic adnexal lesions (a functional cyst and a paraovarian cyst) that were misinterpreted as a single mass on imaging. In one patient, CT revealed the presence of bilateral, benign multicystic adnexal lesions and histology showed three functional ovarian cysts involving the right adnexa and the coexistence of an ovarian cyst and a fibrothecoma in the contralateral ovary. In three cases, the malignant lesions not detected represented microscopic involvement of the contralateral ovary in patients with ovarian malignancies. Two cases of granulosa cell tumors of the ovary, of a diameter less than 0.5 cm, in a patient with a granulosa cell tumor and a fibrothecoma of the contralateral ovary, respectively, were also not detected. One of the six malignancies not detected on MDCT, was a case of bilateral

Table 3
Histopathologic diagnoses for the 143 adnexal masses

<table>
<thead>
<tr>
<th>Pathologic diagnosis</th>
<th>Number of patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benign</td>
<td>96</td>
</tr>
<tr>
<td>Nonneoplastic adnexal cyst</td>
<td>16</td>
</tr>
<tr>
<td>Serous cystadenoma</td>
<td>13</td>
</tr>
<tr>
<td>Mucinous cystadenoma</td>
<td>3</td>
</tr>
<tr>
<td>Benign mixed ovarian tumor (serous, mucinous)</td>
<td>2</td>
</tr>
<tr>
<td>Endometrioma</td>
<td>12</td>
</tr>
<tr>
<td>Teratoma</td>
<td>7</td>
</tr>
<tr>
<td>Fibroma, thecoma or fibrothecoma</td>
<td>8</td>
</tr>
<tr>
<td>Uterine lesions (leiomyoma, adenomyosis)</td>
<td>29</td>
</tr>
<tr>
<td>Pelvic inflammatory disease</td>
<td>5</td>
</tr>
<tr>
<td>Ovarian torsion</td>
<td>1</td>
</tr>
<tr>
<td>Malignant</td>
<td>47</td>
</tr>
<tr>
<td>Serous cystadenocarcinoma</td>
<td>17</td>
</tr>
<tr>
<td>Mucinous cystadenocarcinoma</td>
<td>1</td>
</tr>
<tr>
<td>Endometrioid carcinoma</td>
<td>1</td>
</tr>
<tr>
<td>Mixed malignant ovarian tumor (endometrioid, clear cell carcinoma)</td>
<td>3</td>
</tr>
<tr>
<td>Granulosa cell tumor</td>
<td>3</td>
</tr>
<tr>
<td>Clear cell carcinoma</td>
<td>2</td>
</tr>
<tr>
<td>Borderline ovarian tumor</td>
<td>6</td>
</tr>
<tr>
<td>Undifferentiated carcinoma</td>
<td>1</td>
</tr>
<tr>
<td>Malignant Mullerian mixed ovarian tumor</td>
<td>2</td>
</tr>
<tr>
<td>Adnexal leiomyosarcoma</td>
<td>1</td>
</tr>
<tr>
<td>Ovarian fibrosarcoma</td>
<td>1</td>
</tr>
<tr>
<td>Metastatic adenocarcinoma ovarian in origin</td>
<td>7</td>
</tr>
<tr>
<td>Uterine malignancies (small cell carcinoma of the endometrium, carcinosarcoma)</td>
<td>2</td>
</tr>
</tbody>
</table>

Fig. 5. 57-year old woman with right ovarian fibroma. (a, b) Sagittal MPRs depict an inhomogeneous adnexal mass (star), accompanied by a large amount of ascites and small peritoneal lesions (arrow), of a diameter smaller than 0.5 cm. This was misinterpreted as ovarian malignancy. The peritoneal lesions were attributed to chronic inflammation on pathology.
serous papillary ovarian cystadenocarcinomas, misinterpreted as a large unilateral adnexal mass (Fig. 4).

MDCT examination was accurate to identify the origin of a pelvic mass in 98 (96%) out of 102 patients. In four cases, a pelvic mass was erroneously characterized as adnexal and proved to represent a subserosal degenerated leiomyoma, histologically.

MDCT demonstrated a sensitivity of 90%, a specificity of 88.76%, a positive predictive value of 78.26%, a negative predictive value of 95.18%, and an overall diagnostic accuracy of 89.15% in diagnosing malignancy. The positive and negative diagnostic likelihood ratios were 8 and 0.11, respectively.

There were ten false-positive cases. These included five patients with large adnexal mass lesions, partly cystic-solid in two cases – with solid elements demonstrating mild enhancement after contrast material administration – and a solid mass in the other three cases, inhomogeneously enhancing. These lesions were accompanied by ascites in all patients, and small peritoneal lesions were detected in three cases (Fig. 5). These masses proved histologically to represent stromal ovarian tumors composed of fibrous tissue — ovarian fibrothecomas in two cases, fibromas in other two patients and ovarian thecoma in one case. Among the other false-positive cases, two patients with histologically proved subserosal degenerated leiomyomas, were detected as lesions with enhancing elements on CT, therefore had to be misdiagnosed as malignant. The presence of small papillary projections, interpreted as enhancing components and the associated retroperitoneal lymphadenopathy in two cases with multicystic adnexal mass lesions lead to the preoperative diagnosis of malignancy. A struma ovarii and a salingo-oophoritis, respectively were proved on pathology in these cases. In one patient thought to have ovarian malignancy on MDCT, based on the presence of papillary projections in a large multicystic adnexal mass, histopathology revealed a mucinous cystadenoma.

We had four false-negative cases in this study, histologically proved to represent tumors of low malignant potential. These masses were detected as multilocular benign cystic lesions (Fig. 6) in three cases and as a homogeneous hyperdense adnexal mass lesion in the fourth case, therefore had to be misdiagnosed as benign on imaging.

Among the true-positive cases with ovarian malignancies, five patients had the disease limited to one ovary (stage IA), two in both ovaries (stage IB), one patient had a neoplastic implant to the uterine cavity (stage IIA), and 15 patients had peritoneal metastases outside the pelvis (stage III), including seven cases with peritoneal implants of a diameter smaller than 2 cm (stage IIIB) and eight with peritoneal masses measuring more than 2 cm in diameter (stage IIIC). Three more patients had distant metastases (stage IV), involving the liver in one case, and the lungs, in the other two cases.

Ovarian malignancies in the 26 true-positive cases were staged correctly in 22 (85%). Cases that incorrectly staged on MDCT, included a patient with serous ovarian cystadenocarci-

Fig. 6. 54-year old woman with mucinous ovarian tumor of low malignant potential. Coronal (a) and sagittal (b) MPRs depict a large multicystic ovarian mass, interpreted as benign on imaging. The hyperdense parts (star) are attributed to the presence of mucin.
US in characterizing adnexal malignancies [6,29]. MR imaging is highly sensitive for characterization of an ovarian mass as malignant, MR imaging is considered more specific [12–15].

The introduction of 16-row CT scanners was expected to improve the sensitivity of CT in detecting and characterizing adnexal masses. MDCT scanners have markedly increased volume coverage, combined with decreased scanning time to less than 1 min in most cases [19–21]. A 16-row CT scanner allows the scanning of at least 48 mm long body sections per second (24 mm scanning span per rotation lasting no more than 0.5 s), improving temporal resolution and decreasing drastically the motion artifacts. Another significant technological advancement is the acquisition of thin slices — section collimation of 0.8 mm is routinely employed on 16-row CT scanners. This made possible isotropic imaging, allowing the reformation of images at any plane with spatial resolution identical to the initial scanning plane, as well as the creation of high quality 3D reconstructing. Sixteen-row CT scanners allow for a comprehensive evaluation of the entire abdomen, with scan duration of 15 s on the average, using a slice thickness of less than 1 mm, not resulting in an increase in patient radiation exposure, as proved by measurements in our study. As a result of the CT protocol used in this study, a detailed evaluation of the adnexae was feasible. Determination of the origin of a pelvic mass is difficult, since ovarian and extraovarian masses may share similar morphologic features. However, multiplanar reformataion allowed a confident recognition of the ovaries and an accurate identification of the origin of a pelvic mass, therefore distinguishing between ovarian and extraovarian pelvic masses, as it was the case in 98 (96%) of the 102 patients in this study. An additional MR imaging study could probably prove useful in the identification of the origin of the pelvic mass, in cases that were falsely characterized on MDCT [40,41].

Our study demonstrated an overall diagnostic accuracy of 89.15% in the differentiation of benign from malignant adnexal mass lesions. Due to the acquisition of thin slices and the creation of multiplanar reformatted images, of high resolution, similar to that of axial images, an accurate evaluation of the internal architecture of the adnexal masses and recognition of the ancillary findings to permit a reliable characterization of adnexal mass lesions and to confirm malignancy was possible. Our results are similar to the accuracies reported with studies using transvaginal sonography [4,34,35], or MR imaging [8,10,15] in the characterization and differentiation of adnexal mass lesions. Ueland et al. in a study of 442 ovarian tumors with transvaginal US concluded that morphology indexing is an accurate and inexpensive method in characterizing and differentiating adnexal masses (sensitivity: 98.1%) [35]. Guarriero et al. in a collaborative study of three European departments, of a total of 826 complex adnexal masses reported a specificity of 94% for color Doppler sonography in the diagnosis of adnexal malignancies [34]. Other groups of investigators reported diagnostic accuracies of 91–93% with MR imaging in characterizing adnexal masses [8,10].

We evaluated multiple imaging features to determine the potential likelihood for malignancy. The presence of papillary projections in a cystic lesion and necrosis in a solid mass found to have a statistically significant association with the histologic

<table>
<thead>
<tr>
<th>Table 4</th>
<th>Logistic regression analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Independent variables</td>
<td>Univariate</td>
</tr>
<tr>
<td>Size &gt;4 cm</td>
<td>0.286 → (0.089–0.920)</td>
</tr>
<tr>
<td>Bilateral masses</td>
<td>2.838 → (1.164–6.922)</td>
</tr>
<tr>
<td>Cystic-solid mass</td>
<td>5.096 → (1.632–15.908)</td>
</tr>
<tr>
<td>Necrosis in a solid lesion</td>
<td>8.820 → (2.881–27.005)</td>
</tr>
<tr>
<td>Thick wall, septa</td>
<td>1.533 → (0.519–4.527)</td>
</tr>
<tr>
<td>Wall or septal irregularity</td>
<td>6.933 → (1.381–34.802)</td>
</tr>
<tr>
<td>Pelvic wall invasion</td>
<td>9.917 → (2.602–37.797)</td>
</tr>
<tr>
<td>Lymphadenopathy</td>
<td>6.933 → (1.381–34.802)</td>
</tr>
</tbody>
</table>

Dependent variable histological diagnosis.
diagnosis of malignancy. These primary imaging findings were also found to be the most significant indicators for malignancy in other reports, using MR imaging in adnexal mass characterization [8,10,15]. Ancillary findings, like peritoneal metastases were also proved to be strongly indicative of malignancy, reported also by the same investigators [8,10,15].

Ovarian cancer is usually in advanced stage at diagnosis — which was the case in 18 (69%) of the 26 true-positives in this study, and peritoneal seeding is the commonest mode of metastatic spread. Single-detector row CT scanners had a sensitivity of 85–93% for the detection of peritoneal metastases, but the sensitivity was dramatically reduced to 25–50% for tumor implants of 1 cm or smaller in diameter [42]. Multi-detector row CT scanners improved the sensitivity of CT in detecting peritoneal carcinomatosis, due to the acquisition of thin slices and the creation of high quality MPRs, therefore allowing the recognition of sub centimeter implants and the detailed evaluation of curved structures, like the undersurface of the diaphragms, paracolic gutters and pelvis [24,25]. In our study, MDCT allowed the correct indentification of all cases of peritoneal carcinomatosis in patients with ovarian malignancies (15 out of 15). These included seven cases with peritoneal implants larger than 2 cm and eight cases with implants of a diameter smaller than 2 cm. Three patients had peritoneal lesions smaller than 0.5 cm in diameter and in five cases, lesions smaller than 0.5 cm were found to coexist with larger ones, all detected on MDCT. Multiplanar reformatted images allowed a detailed evaluation of the different peritoneal compartments and a reliable recognition of any minimal nodularity of peritoneal surfaces (Fig. 7), implying peritoneal infiltration. Special MPRs have been proved more useful for the evaluation of certain peritoneal compartments: sagittal and coronal reformations, which allow a better evaluation of the diaphragms; coronal reformatted images proving useful for the detailed assessment of the paracolic gutters, enabling the recognition of even small nodularity of the peritoneum (Fig. 7); sagittal plane proving valuable for the assessment of Douglas space [25].

Processing of the CT data in our study included also the performance of 3D reconstructed images. These images enabled a representative evaluation of tumor volume and of the extent of the disease (Fig. 1) in a similar way, as seen during surgery and proved extremely useful in preoperative planning.

Possible limitations of multidetector CT included difficulty in revealing microscopic disease or small-sized tumors (of a diameter smaller than 0.5 cm), and defining whether a large adnexal mass was unilateral or bilateral. These problems are met whether MDCT or other imaging technique is used. MDCT also incorrectly classified four cases of tumors of low malignant potential, which were characterized as benign on imaging. The evaluation of these tumors is often difficult, because their imaging characteristics are similar to those of benign lesions [29,30,43], as it was also in this study. Papillary projections, on the other hand is considered a characteristic finding of ovarian borderline malignancies, as are more often abundant in these neoplasms, and less commonly seen in benign cystic ovarian tumors [43,44]. However, in our study the presence of papillary projections led to the false-positive diagnosis in a case of a multicystic ovarian tumor, which proved to represent a mucinous cystadenoma on histology.

The presence of irregularly thickened walls, papillary projections, and enhanced solid elements on imaging might be specific indicators for ovarian mass malignancy. But, this proved incorrect in nine cases in this study, including one patient with pelvic inflammatory disease, two cases with subserosal degenerated leiomyomas, five with stromal ovarian tumors composed of fibrous tissue and one patient with struma ovarii. The latter cases could probably be accurately characterized on a supplementary MR imaging examination, based on the predominantly low signal intensity of the collagen content of stromal tumors, or the presence of areas of signal void in struma ovarii, on T2-weighted images, respectively [45–48].

Peritoneal disease, including both neoplastic and nonneoplastic conditions is usually manifested on CT imaging as fluid accumulation and presence of masses or infiltration of the various peritoneal ligaments and mesenteries [49]. The pathways of spread of disease are similar for both neoplastic and inflammatory conditions [50]. The imaging findings are usually nonspecific and the correct characterization of the nature either of ascites or peritoneal lesions may not be possible, especially in cases in which adnexal masses are found to coexist. In this study, we had nine cases in which peritoneal disease proved nonmetastatic on histology, one patient with bilateral pyosalpinx, in whom peritoneal infiltration proved inflammatory on pathology and five patients with stromal ovarian tumors composed of fibrous tissue, accompanied by ascites in all cases and small peritoneal lesions in three patients — the latter proved of chronic inflammatory origin, histologically (Fig. 5).

Fig. 7. 23-year old woman with bilateral serous ovarian tumors of low malignant potential. Coronal MPR depicts bilateral cystic adnexal mass lesions (stars) with solid elements, not seen in this image. There is also peritoneal thickening and slight irregularity (arrows) involving the paracolic gutters, proved histologically to represent desmoplastic non-invasive peritoneal metastases.
Three more patients with ovarian malignancies were incorrectly staged as stage IC on MDCT, and ascites proved nonneoplastic pathologically.

Serum CA 125 levels is a known, extremely useful preoperative test for the detection of epithelial ovarian cancer and the differentiation between benign and malignant adnexal masses, also proved valuable in the clinical follow-up of patients with ovarian malignancies. [29,51,52] No correlation of the diagnostic performance of multidetector CT and CA 125 levels was performed in our study and this represents a limitation.

Another important issue related to the choice of the technique to be used in the imaging evaluation of adnexal masses is the cost. Transvaginal US is charged much less than CT examination of the abdomen, and even less when compared to MR imaging examination of the pelvis. Based on the results of the present study, multidetector computed tomography could be a cost-effective next step in the evaluation of adnexal masses, when the results of the US examination are indeterminate or suspicious of malignancy, especially when taking into consideration the advantages of computed tomography compared to the MR imaging examination, that is the short examination time, the wider availability and the lower cost. A large prospective study comparing the diagnostic performances of multidetector computed tomography to that of sonography and MR imaging is needed to justify the role of MDCT in the imaging algorithm of adnexal mass lesions.

Computed tomography is an easily reproducible technique, widely available and easily understood. CT is usually used in the follow-up of ovarian malignancies and therefore a baseline CT examination is mandatory for future comparison in these patients. Computed tomography has also been accepted as a reliable preoperative imaging technique in selecting patients with advanced ovarian carcinoma at high risk for suboptimal initial cytoreductive surgery. [53,54] Multidetector CT on a 16-row CT scanner provided a fast and detailed evaluation of the abdomen.[53,54] Multidetector CT on a 16-row CT scanner provided a fast and detailed evaluation of the abdomen, allowing a high detection rate for adnexal masses, an accurate discrimination of ovarian from extraovarian pelvic masses and a reliable differentiation between benign and malignant adnexal mass lesions in our study. The technique can be recommended as a reliable imaging modality to detect and characterize adnexal mass lesions, to provide staging information for preoperative planning and to predict suboptimal debulking in patients with ovarian malignancies.

Conflict of interest statement
The authors have no conflicts of interest to declare.

References


