Taiwanese Journal of Obstetrics & Gynecology 57 (2018) 40–46

Contents lists available at ScienceDirect

Taiwanese Journal of Obstetrics & Gynecology

journal homepage: www.tjog-online.com

Original Article

Characterization of tubo-ovarian abscess mimicking adnexal masses: Comparison between contrast-enhanced CT, ^{18}F–FDG PET/CT and MRI

Hua Fan [a], Ting-Ting Wang [a], Gang Ren [a], Hong-Liang Fu [b], Xiang-Ru Wu [c], Cai-Ting Chu [a], Wen-Hua Li [a, *]

[a] *Department of Radiology, Xinhua Hospital Affiliated to Shanghai Jiao Tong University School of Medicine, 1665 Kong Jiang Road, Shanghai 200092, China*
[b] *Department of Nuclear Medicine, Xinhua Hospital Affiliated to Shanghai Jiao Tong University School of Medicine, 1665 Kong Jiang Road, Shanghai 200092, China*
[c] *Department of Pathology, Xinhua Hospital Affiliated to Shanghai Jiao Tong University School of Medicine, 1665 Kong Jiang Road, Shanghai 200092, China*

A R T I C L E I N F O

Article history:
Accepted 8 November 2017

Keywords:
CT
DWI
MRI
PET
Tubo-ovarian abscesses

A B S T R A C T

Objective: We compared the diagnostic accuracy of contrast-enhanced computed tomography (CT), fluorine 18-labeled–fludeoxyglucose (^{18}F–FDG) positron emission tomography (PET)/CT and conventional magnetic resonance imaging (MRI) without and with diffusion-weighted imaging (DWI) for characterization of tubo-ovarian abscesses (TOAs) that mimic adnexal tumors.
Materials and Methods: We evaluated (retrospectively) 43 patients who underwent contrast-enhanced CT, PET/CT, conventional MRI without and with DWI, and who were found to have TOAs and complex adnexal tumors. All images were evaluated independently by four radiologists using a two-point grading system. Results of contrast-enhanced CT, PET/CT, MRI without DWI, and MRI with DWI were compared for each patient using receiver operating characteristic curves. Sensitivity, specificity, and positive predictive value (PPV) were calculated and compared using the chi-square test.
Results: Sensitivity of MRI with DWI (95%) was significantly higher than that of contrast-enhanced CT (78.6%), PET/CT (86.7%) and MRI without DWI (87.5%). Specificities of these modalities were not significantly different. The PPV of MRI with DWI (100%) was significantly higher than that of the other three modalities (CT, 72.4%; PET/CT 78.5%; MRI without DWI, 81.5%). Overall accuracy of MRI with DWI was significantly higher than that of the other three modalities (CT, 74.4%; PET/CT, 81.4%; MRI without DWI, 83.7%).
Conclusion: MRI with DWI shows high accuracy for characterization of complex ovarian lesions, and is the most useful method for differentiation of TOAs from ovarian tumors.

Introduction

The clinical diagnosis of pelvic inflammatory disease, including tubo-ovarian abscesses (TOAs), is based mainly on the basis of symptoms and signs: pain in the lower abdomen, fever, increased levels of C-reactive protein in blood, and adnexal tenderness. Gastroenterological problems, urinary tract infections, and other gynecologic disease may simulate pelvic inflammatory disease, and some types of chronic pelvic inflammatory disease may mimic malignancy exactly [1–5]. Thus, ascertaining whether a clinically diagnosed complex cystic or cystic-solid mass is inflammatory, benign or malignant is frequently not possible because they include a wide spectrum of inflammatory and neoplastic conditions, ranging from hydrosalpinx to TOAs and from cystadenoma through borderline-to-invasive malignancies. A reliable method to differentiate a benign condition from a malignant condition would provide a basis for optimal preoperative planning, and could reduce the number of unnecessary laparotomies.

Positron emission tomography/computed tomography (PET/CT) combines the anatomic and functional details depicted with CT and metabolic information obtained with PET. Hence, PET/CT yields more precise anatomic information and reduces the number of equivocal PET interpretations. PET/CT and CT have disadvantages, however, such as radiation exposure and limited depiction of small volumes of metabolically active tumors [6–8].

* Corresponding author. 1665 Kongjiang Road, Shanghai, China. Fax: +86 2165795173.
E-mail address: liwenhua@xinhuamed.com.cn (W.-H. Li).

https://doi.org/10.1016/j.tjog.2017.12.007
1028-4559/

Studies have shown that diffusion-weighted imaging (DWI) can facilitate non-invasive characterization of biologic tissues based on their water-diffusion properties. It yields information about the biophysical properties of tissues: organization and density of cells, microstructure, and microcirculation. Some researchers [9–12] have found that high b-value DWI with measurement of the apparent diffusion coefficient (ADC) is useful in tissue (including serous fluid, mucinous fluid, and pus) and for blood characterization.

Few studies have been conducted comparing contrast-enhanced CT, PET/CT, and magnetic resonance imaging (MRI) with and without DWI for detection of inflammatory and non-inflammatory lesions in the pelvis. Here, we wished to ascertain if addition of a DWI protocol to conventional MRI could be used to help differentiate a pseudo-solid area (pus) from other fluid components.

Methods and methods

Patients

The study protocol was approved by our institutional ethics committee and written informed consent was obtained from all patients. Between January 2008 and May 2016, a DWI sequence was added to conventional MRI for each woman with clinically suspected pelvic inflammatory disease and adnexal masses. We retrospectively analyzed a consecutive population of 336 women who satisfied the following inclusion criteria: (i) history of acute pelvic pain or lower abdominal pain of <3 week duration with or without fever; (ii) lower abdominal tenderness; (iii) bilateral adnexal tenderness and cervical motion tenderness; (iv) increased levels of C-reactive protein (>10 mg/L); (v) increased levels of cancer antigen-125 (>35 UI/L); (vi) available data of contrast-enhanced CT, PET/CT, and MRI with DWI.

The imaging database was reviewed, and subjects who underwent laparoscopy and surgery subsequently were selected. Patients with malignant tumors of the colorectal tract (n = 96) or genitourinary tract (n = 68), endometriomas or hemorrhagic cysts (n = 61), endometrial malignancy (n = 19), hydrosalpinx (n = 16), mature/immature teratomas (n = 15), ovarian fibromas or cystadenofibromas (n = 11), free pelvic fluid only (n = 5), or DWI artifacts (n = 2) were excluded to limit the risk of selection bias [13,14]. Conventional MRI can provide an appropriate diagnosis for endometriomas, mature teratomas, hydrosalpinx, fibromas, cystadenofibromas, and free pelvic fluid, so, these lesions are excluded. The final cohort comprised 43 patients. All these patients were collected and screened by the first author (F.H.).

Image acquisition parameters

CT studies were done using a dual-source 64-channel multidetector CT system (Somatom Definition; Siemens Healthcare, Forchheim, Germany). All patients received 150 mL of 60% iodinated contrast (iohexol (Omnipaque 350); Nycomed Amersham, Little Chalfont, UK) administered via the intravenous route with a power injector at 3 mL/s as well as 800 mL of diatrizoate meglumine (Hypaque, Nycomed Amersham) administered via the oral route. Acquisition of images in the portal venous phase was done with 5–6 mm collimation 60s after injection of contrast material.

In PET/CT examination, all patients fasted for ≥6 h and maintained blood glucose levels <150 mg/dL before PET using ^{18}F–FDG, but oral hydration with glucose-free water was permitted. Patients were allowed to rest in a supine position 40–60 min after injection of ^{18}F–FDG (3 MBq/kg body weight, i.v.). Then, they were positioned for PET/CT. The latter was done on a combined dedicated PET/CT system (Biograph 64; Siemens Healthcare). A CT image was acquired from the top of the head to mid-thigh without specific instructions for breath-holds. CT parameters were 140 kV, 80 mA, and a slice thickness of 5 mm. CT was followed by PET covering the same transverse field of view during normal breathing. Imaging was acquired with 6–8 bed positions on three-dimensional mode for 3 min per bed position. PET images were reconstructed iteratively using contrast-enhanced CT data for attenuation correction. Co-registered images were displayed on a workstation using dedicated software that allowed viewing of PET, CT and fusion images on trans axial, sagittal and coronal displays.

MRI was done using 3.0-T MR scanners (Signa; GE Medical Systems, Milwaukee, WI, USA) using a torso phased array coil. Axial non-contrast T1-weighted (TR/TE range, 400–600/10–14 ms) and axial T2-weighted (4000–6000/100–120 ms) imaging was done with a chemical shift-selective fat saturation pulse using the following parameters: slice thickness, 6 mm; gap, 1 mm; field of view (FOV), 32–42 cm; matrix, 256 × 256; excitation, 2. Sagittal T1-weighted and T2-weighted (TR/TE range, 3000–6000/100–110 ms) fast spin-echo imaging without chemical shift-selective fat saturation pulses were also under taken, as well as post-contrast enhanced axial and sagittal T1-weighted imaging, using the same parameters as those described above except that a slice thickness of 6 mm was used. DWI-MRI was acquired in the axial plane before administration of contrast medium using a single-shot echo-planar imaging sequence (TR/TE effective range, 8000–10,000/70–100; slice thickness, 6 mm; gap, 1 mm; FOV, 32–42 cm; matrix, 128 × 128; excitation, 2). Also, b values of 0 and 1000 s/mm^2 were applied in three orthogonal (Z, Y, X) directions.

Image analyses

CT data and data for conventional MRI with DWI were reviewed by two radiologists who had 12 years and 13 years of experience in gynecologic imaging. PET/CT images were reviewed by two physicians with expertise in nuclear medicine. Reviewers making assessments of contrast-enhanced CT, MRI and PET/CT were blinded to laparoscopic and pathologic diagnoses of lesions, and assessed all images together in two steps. In the first step, one radiologist measured and recorded the lesion size, standardized uptake value (SUV), and ADC of cystic cavities used for comparison. When the lesion exhibited a multilocular cystic mass, 2–3 regions of interest (ROIs) were drawn within the high signal intensity cystic components, and when the lesion was unilocular, only one ROI was used. The mean size of ROIs varied from 18 to 120 mm^2. To minimize variability, the final ADC value of each patient was determined by the average results of all measured ROIs. In the second step, agreement of the four reviewers was reached after careful evaluation of size, shape, and character (cystic-solid) of the lesion; density of cystic and solid components on CT; signal intensity of cystic and solid components on T1-, T2-, and DWI; PET/CT fusion images by visual inspection. Then, lesions were characterized using a two-point scale: 1 = TOA, 2 = non-TOA (including tumors and ruptured tubal pregnancy).

Statistical analyses

Laparoscopic and surgical pathologic findings were used as reference standards for qualitative assessment of adnexal lesions. Analyses were done using SPSS v17.0 (IBM, Armonk, NY, USA). Quadratic K coefficients were calculated to assess interobserver agreement for contrast-enhanced CT, PET/CT, conventional MRI without DWI, and MRI with DWI with regard to lesion characterization. Rating of “1” suggested a TOA and was accepted as being a