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Multidetector-row computed tomography (MDCT) findings of adnexal torsion: An analysis of 116 patients

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KEYWORDS
Adnexal torsion; Ovary; Fallopian tube; Multidetector computed tomography; Ovarian tumor

Abstract
Purpose: The purpose of this study was to identify differences in multidetector-row computed tomography (MDCT) findings of adnexal torsion (AT) according to the anatomical subtypes and identify MDCT findings that may predict conservative treatment.

Materials and methods: A total of 295 consecutive women with pelvic pain who underwent preoperative MDCT and subsequent surgery less than 24 h after admission were included in this retrospective study. Among them, 116 women (mean age: 33.9 years; range: 3–80 years) with histopathologically confirmed AT after surgery were included in the final analysis.

Results: On histopathological examination, an underlying ovarian mass was found in 98 women (98/116, 84.5%). In the group without ovarian mass (n=18), massive edema (12/18, 66.7% vs. 16/98, 16.3%; P<0.001) was frequently found. However, in the group with ovarian mass (n=98), twisted tube or pedicle (5/18, 27.8% vs. 55/98, 56.1%; P=0.027) and concentric or eccentric wall thickening (5/18, 27.8% vs. 82/98, 83.7%; P<0.001) demonstrated a statistically significant higher incidence. Based on the surgical and pathological results, the 116 women were classified into three subtypes including ovary-tubal (89/116, 77%), ovary only (22/116, 19%) and tubal only subtype (5/116, 4%). In the ovary-tubal subtype, tubal thickening (88/89, 98.9% vs. 11/22, 50.0%; P<0.001), twisted tube or pedicle (57/89, 64.0% vs. 3/22, 13.6%; P<0.001) and remaining tubal enhancement (52/89, 58.4% vs. 7/22, 31.8%; P=0.025) were more frequently

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Adnexal torsion (AT) is a rare but serious cause of acute abdominal and pelvic pain in women, accounting for 2.7% of gynecological emergencies [1]. Early diagnosis and surgical intervention are needed to preserve the ovary and prevent irreversible damage [1]. Multidetector-row computed tomography (MDCT) has been shown more effective and precise than ultrasonography with color Doppler study for the evaluation of AT [1—4]. Although imaging findings of AT may be variable according to the mechanism and degree of vascular compromise, twisted pedicle or thickening tube has been known as the most specific finding [3,5]. Another previous study that analyzed torsions involving the ipsilateral ovary and the fallopian tube simultaneously also demonstrated that peculiar uterine tube thickening and eccentric or concentric wall thickening are the most specific findings of AT [6]. Twisted pedicles may consist of various components such as the fallopian tube, mesoovarium, broad ligaments, suspensory ligament, ovarian vessels and branches of the uterine vessels. Twisted pedicle of torsion involving only the ovary may not include the fallopian tube component and has lower incidence of peculiar fallopian tube thickening. In general, AT can be categorized into 3 subtypes (ovary and fallopian tube, only ovary and only fallopian tube) based on involved anatomical structures. To best of our knowledge, there is no study on difference in MDCT findings based on aforementioned subtypes [2,3,5—7].

Our study was aimed at finding out whether there is a difference in frequency of MDCT findings of AT depending on anatomical subtypes and identifying MDCT findings that may be used to help select the optimal treatment strategy.

Materials and methods

Patient groups

Our institutional review board approved this retrospective evaluation of patient records and images. The requirement for informed consent was waived.

From January 2004 to December 2014, through a search of the database of our hospital, 295 consecutive women referred for MDCT examinations because of pelvic or lower abdominal pain at our institute’s emergency department and were managed by emergency operations in the obstetrics department were identified. A total of 179 women with ovarian cystic rupture, ectopic pregnancy rupture, tuboovarian abscess and ovarian cancer with peritoneal seeding were excluded from this study. Ultimately, 116 women (mean age: 33.9 years; range: 3—80-year-olds) with histopathologically confirmed AT after surgery were included in the final analysis. According to the involved adnexal structures, 89 women had torsions involving both the ovary and the fallopian tube, 22 women had only ovarian torsion and 5 women had isolated tubal torsion.

MDCT technique

All MDCT examinations were obtained using one of the following commercially available MDCT scanners (71 women using Definition AS+, 42 patients using Sensation 16, 3 women using Volume Zoom; Siemens Medical Solutions, Forchheim, Germany). In total, 120 mL non-ionic iodinated contrast agent (lopromide, Ultravist, 300 mg/mL; Schering, Seoul, Korea) were administered intravenously using a mechanical injector at a rate of 2 mL/s. The scanning delay was 70—120s. All women underwent scanning in the supine position, starting from the diaphragm down to the symphysis pubis. Unenhanced examinations were performed including only the pelvic area in 23 women. Oral contrast material (1000 mL meglumine ioxithalame, Telebrix 3%, Guerbet, Roissy-Charles de Gaulle, France) was administered to 12 women 90 min before MDCT. The most commonly used parameters for 128 MDCT examinations were as follows: 100 kVp; quality reference current: 220 mAs; detector configuration: 0.6 × 32 mm; pitch: 1.25; rotation time: 0.5 s; section thickness: 4.0 mm; reconstruction interval: 4 mm; and reconstruction kernel: B30f. Tube current modulation using CAREDose4D (Siemens Medical Solutions) was used. Routine transverse and coronal images were reconstructed on a standard workstation (Syngo Multi-Modality Work Place, Siemens Medical Solutions).

Imaging interpretation

Two radiologists, each with more than 10 years of clinical experience in body imaging, reviewed all MDCT examinations with knowledge of the anatomical subtypes of AT in each subgroup. Our analysis of the imaging findings that were modified based on data from Hiller et al. and Lee et al. [2,6] and included evaluation of:

- the maximal adnexal size including underlying mass;
- presence of associated ovarian mass;
- massive ovarian edema (edematous enlargement of the ovary with or without underlying mass);

observed than in the ovary only subtype. There was no significant difference between the relative frequency of imaging findings in the cystectomy group and adnexitomy group of the ovary-tubal type.

Conclusions: Knowledge of common and characteristic MDCT findings of AT according to the anatomical subtypes is important to make accurate diagnosis and avoid delayed treatment.

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• mural thickening (mural thickening seen only in the twisted cystic adnexal mass was considered thickened if it exceeded 3 mm);
• misplacement of the adnexa to contralateral side;
• deviation of the uterus to the side of the involved ovary;
• tubal thickening (> 3 mm);
• the twisted tube or pedicle;
• hyperattenuating follicular sign;
• remaining tubal enhancement.

The finding of massive ovarian edema was defined as detection of enlarged ovary with or without underlying mass combined with discernible, multiple, peripherally located follicles. Misplacement of the adnexa to contralateral side was defined as midline cross of the epicenter of torsed adnexal structure and mass. Hyperattenuating follicular sign was defined as presence of cystic lesion with hyperattenuating rim at the same enhancement level of contralateral adnexa. Remaining tubal enhancement revealed presence of kinked or dilated vessel like enhanced portion in the thickening or torsed tube. Consensus between the two radiologists was reached on any difference in opinion at the regular conference with additional opinion from a third blinded radiologist when necessary.

Statistical analysis

Clinical and demographic data were reported with descriptive statistics. Differences in imaging findings (OT group versus O group, group without ovarian mass versus underlying mass group, cystectomy group versus adnexectomy group) were analyzed using Fisher’s exact test for proportions. Statistical analyses were performed using SPSS software (ver. 13.0; SPSS, Inc., Chicago, IL, USA). P-values < 0.05 were taken to indicate statistical significance.

Results

Common symptoms were abdominal or pelvic pain (100%) and nausea/vomiting (85/116, 73.3%). There was a slight right-sided predominance (66/116, 56.9%). The mean size of ovary including mass in the right adnexa and the left adnexa were 9.6 cm (range: 4.5–26 cm) and 10.2 cm (range: 5.4–28 cm), respectively. On pathologic examination, an underlying ovarian mass was found in 98 women (98/116, 84%). The final diagnoses of the underlying ovarian mass included benign cystic teratomas (n = 38), follicular cyst (n = 6), corpus luteal cysts (n = 20), serous cystadenomas (n = 8), mucinous cystadenomas (n = 17), fibromas (n = 4), borderline tumors (n = 2) serous, n = 1 mucinous), malignancy (n = 1, adenocarcinoma, suspected Krukenberg tumor) and unclassified hemorrhagic ovarian cyst (n = 1). Nine women had only paratubal cysts without discernible ovarian mass and nine women had small functional cysts (< 3 cm) that could not carry the risk of ovarian torsion. The differences between the relative frequency of the group without ovarian mass (n = 18) and group with underlying ovarian mass (n = 98) are summarized in Table 1. In the group without ovarian mass, massive edema was more frequently observed (12/18 66.7% vs. 16/98, 16.3%; P < 0.001). However, in the underlying mass group, twisted tube or pedicle (5/18, 27.8% vs. 55/98, 56.1%; P = 0.027) and concentric or eccentric wall thickening (5/18, 27.8% vs. 82/98, 83.7%; P < 0.001) were more frequently observed.

Based on the surgical and pathological results, the total 116 patients were classified into three subtypes including the ovary-tubal (OT) (89/116, 77%, torsion involving both the ovary and the fallopian tube) (Fig. 1), the ovary only (O) (22/116, 19%, only ovarian torsions) (Fig. 2) and the tubal only (T) subtype (5/116, 4% isolated tubal torsion) (Fig. 3). The results of the comparison of imaging findings between OT subtype and O subtype are reported in Table 1. Tubal thickening (88/89, 98.9% vs. 11/22, 50.0%; P < 0.001), twisted tube or pedicle (57/89, 64.0% vs. 3/22, 13.6%; P < 0.001) and remaining tubal enhancement (52/89, 58.4% vs. 7/22, 31.8%; P = 0.025) were more frequently observed in the OT subtype than in the O type (Figs. 4 and 5).

In the OT subtype, ipsilateral adnexectomy (salpingo- oophorectomy) was performed in 68 women and cystectomy with detorsion in 21 women. One woman with contralateral ovarian mass was performed contralateral ovarian wedge resection. The differences between the relative frequency of imaging findings in the cystectomy group and adnexectomy group of the OT subtype were as follows: ovarian mass (19/21, 90.5% vs. 60/68, 88.2%; P > 0.99), massive edema (3/21, 14.3% vs. 19/68, 27.9%; P = 0.25), tubal thickening (21/21, 100% vs. 67/68, 98.5%; P < 0.99), twisted tube or pedicle (11/21, 52.4% vs. 46/68, 67.6%; P = 0.20), concentric or eccentric wall thickening (16/21, 76.2% vs. 54/68, 79.4%;

<table>
<thead>
<tr>
<th>Table 1</th>
<th>MDCT findings according to presence of mass and the subtypes.</th>
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<tbody>
<tr>
<td></td>
<td>Without ovarian mass (n = 18)</td>
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<tr>
<td>Ovarian mass</td>
<td>0 (0%)</td>
</tr>
<tr>
<td>Massive edema</td>
<td>12 (66.7%)</td>
</tr>
<tr>
<td>Tubal thickening</td>
<td>15 (83.3%)</td>
</tr>
<tr>
<td>Twisted tube</td>
<td>5 (27.8%)</td>
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<tr>
<td>Wall thickening</td>
<td>5 (27.8%)</td>
</tr>
<tr>
<td>Misplacement to contralateral side</td>
<td>6 (33.3%)</td>
</tr>
<tr>
<td>Hyperattenuating follicle</td>
<td>7 (38.9%)</td>
</tr>
<tr>
<td>Remaining tubal enhancement</td>
<td>6 (33.3%)</td>
</tr>
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Figure 1. A 34-year-old woman with OT subtype torsion with follicular cyst of left ovary: a: contrast material enhanced MDCT image in the transverse plane; b: in the coronal plane show a unilocular, well-defined cystic mass with diffuse and concentric wall thickening and a peculiar amorphous eccentric tubal thickening (arrows) in the upper lateral border. Hemorrhagic follicular cyst was confirmed after laparoscopic left adnexectomy, with 360° counter-clockwise rotation.

Figure 2. A 46-year-old woman with O type torsion: a: contrast material enhanced MDCT images in the transverse plane; b: in the coronal plane show massive ovarian edema with peripherally located follicles (arrowheads). A laparoscopic right adnexectomy was performed, and a hemorrhagic cyst was noted with 720° counter-clockwise rotation. Hemorrhagic ovarian cyst with necrosis was noted at histopathological analysis.

P = 0.75, misplacement to contralateral side (10/21, 47.6% vs. 33/68, 48.5%; P = 0.94), hyperattenuating follicle sign (5/21, 23.8% vs. 14/68, 20.6%; P = 0.75), remaining tubular enhancement (16/21, 76.2% vs. 36/68, 52.9%; P = 0.75). There was no significant difference between the relative frequency of imaging findings in the cystectomy group and adnexectomy group of the O-T type.

In the O type, ipsilateral adnexectomy was performed in 6 patients and cystectomy with detorsion in 16 patients. One patient had history of previous hysterectomy. In MDCT features, ovarian mass was identified in 86.4% (19/22), massive edema in 27.3% (6/22), tubal thickening in 50.0% (11/22), twisted tube or pedicle in 13.6% (3/22) concentric or eccentric wall thickening in 59.1% (13/22), misplacement

Figure 3. A 37-year-old woman with T type torsion: a: contrast material enhanced MDCT image in the coronal plane; b and c: contrast material enhanced MDCT images in the transverse plane show left isolated tubal torsion (arrowhead at torsion knot and paratubal cyst at open arrow) with discernible ipsilateral intact ovary (arrow). Laparoscopic left salpingectomy was performed, and a 9-cm torsed paratubal cyst was noted with 720° clockwise rotation.
to contralateral side in 54.5% (12/22), hyperdense follicle sign in 27.2% (6/22) and remaining tubular enhancement in 31.8% (7/22).

In the T type ipsilateral, adnexectomy was performed in one patient, cystectomy with detorsion in two patients and salpingectomy in one patients. In MDCT findings, tubal thickening was delineated in 100% (5/5), concentric or eccentric wall thickening in 40% (2/5), misplacement to contralateral side in 20% (1/5) and hyperdense follicle sign in 40% (2/5, 40%). Ovarian mass, massive edema, twisted tube or pedicle and remaining tubular enhancement were not noted in the type of AT.

**Discussion**

AT is a partial or complete twisting of adnexal structures including the ovary, fallopian tube and its ligamentous supports containing vessels for ovarian blood supply. Torsion of adnexal structures may involve only the ovary (O subtype) or the fallopian tube (T subtype), but more often, it involves both (OT subtype) [6–8]. Regarding the involved anatomical structures, the components of the twisted pedicles may be variable. In OT subtype, twisted pedicles include the fallopian tube, broad ligament and adnexal branch of the uterine artery. However, O subtype torsion has the twisted pedicle composed of the meso-ovarium and ovarian vessels [7,8]. In our study, twisted tube only was more frequent than ovary-tube torsion. This implies that the twisted pedicle is less frequently observed in the O group due to the relatively thicker internal tubal components. Three women in the O group displayed thick tube-like structures probably because the engorged and edematous vessels within and around the mesoovarium mimicked twisted tube-like appearance. The sequential pathophysiology of AT is as follows: initially, a twisted ovarian pedicle and fallopian tube compromise venous and lymphatic outflow, resulting in congestion and diffuse ovarian edema followed by arterial obstruction and thrombosis. Massive ovarian edema refers to a tumor-like enlargement of the ovary due to outflow obstruction resulting in edematous fluid retention in the stroma. The affected ovary reveals diffuse edematous swelling with separated and peripherally located follicles.
In our study, women without detectable ovarian mass showed ovarian edema more frequently than those with visible ovarian mass. We suspect that the portion of normal ovarian stroma turning into massive edema in this group is larger than that in the ovarian mass group that has less intact stroma due to replacement by tumor. Therefore, a smaller stroma portion may be affected by outflow obstruction and lead to less detectability. Persistent vascular compromise leads to hemorrhagic infarction and necrosis of the affected ovary [5,7,8].

MR imaging aids in the detection of the hemorrhagic infarction. MR imaging is superior to other imaging due to its inherent tissue contrast, discernibility of tissue components, detectability of enhancement and presence of hemorrhagic infarction [7,9–11]. Hemorrhage on T1-weighted images with lack of contrast enhancement is suggestive of irreversible ischemic change [11,12]. Although MR imaging used in conjunction with intravenous administration of a gadolinium chelate gives excellent anatomical details and information for tissue component, limited scan range and high financial burden may hinder more widely clinical usage.

For the diagnosis of ovarian torsion, the modality of choice has been color Doppler ultrasonography [8]. Although Chiou et al. reported lower diagnostic value of CT by comparison with ultrasonography, the difference was not significant [13]. Additionally, the use of coronal reforma-
tion with transverse MDCT images improves the detection of AT [14]. A twisted pedicle is composed of the fallopian tube, broad ligament and ovarian branches of the uterine vessel [8,14], which corresponds to the “whirlpool sign” on Doppler ultrasonography, although it is not commonly seen. The prevalence of this finding in patients with AT varies between 13 and 88% on ultrasonography and in less than 33% on CT [2,8]. The likelihood of this finding depends on the degree of torsion, edema, hematoma filling and its location. Our results for delineating a twisted tube or pedicles were 51.7% (60/116), which is a relative high percentage, and might be due to improved accumulated knowledge of AT. In case that findings of twisted tube or pedicle are not detected on CT scans, other ancillary findings such as tube thickening, cyst wall thickening and massive edema could be useful signs for diagnosis. In addition, further investigation of clinical findings in women of reproductive age with acute abdominal pain is meaningful when a high level of suspicion for AT is present, because timely management is crucial to salvaging the ovary. Although transvaginal ultrasound with Doppler has been used typically as the first-line and optimal imaging, MDCT may be the initial diagnostic imaging examination performed in recent years for the work-up of women presenting with acute lower abdominal or pelvic pain of unknown cause [1]. The major criticism of CT imaging for younger women patient is the risk of exposure to ionizing radiation. However, ultrasonography can be limited by false-negative rates as high as 45–61% [1,3]. Furthermore, the use of dose reduction technology such as low kilo-voltage technique and iterative reconstruction allow obtaining low dose abdominopelvic MDCT [15].

The most commonly accepted treatment in AT is adnexectomy when ovarian viability is uncertain. However, several previous reports showed that conservative treatment
including detorsion and cystectomy might result in preservation of ovarian function and fertility [16—18]. Previously, adnexectomy was commonly undertaken to avoid possible thromboembolism during detorsion. However, McGovern et al. reported the rare incidence of pulmonary embolism in only 0.2% of 1000 cases [18]. Nowadays, detorsion of the adnexa and consecutive removal of specific ovarian lesion is generally recommended for AT treatment. Our results showed no significant difference in imaging findings between the detorsion-cystectomy group and the adnexectomy group. No specific imaging findings indicative of predictors for successful conservative therapy were found. The relative high rate of adnexectomy in our study is possibly because of the long-term data collection that had included patients treated with somewhat outdated therapeutic strategy and severe ischemia of ovaries may necessitate more extensive removal than cystectomy.

Our study has several limitations. First, our study was retrospective and under non-randomized study design. Verification or selection bias may have distorted the true diagnostic performance because we only included patients who underwent preoperative MDCT and surgery. Second, the readers were instructed to search specifically for AT on CT, which may increase in detection rate of each finding.

In conclusion, among the MDCT features, tubal thickening is the most frequently noted finding, especially in OT subtype of AT. Precise awareness of more frequent MDCT findings according to the anatomical subtypes may help make accurate diagnosis and avoid the delayed treatment in AT.

Disclosure of interest

The authors declare that they have no competing interest.

References


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