Retrospective Image Observation of Ectopic Pregnancy on Computed Tomography in the Emergency Condition: How Useful is Adnexal Ring Sign?

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ABSTRACT

Ectopic pregnancy is a major cause of first-trimester death in pregnancy, and standard clinical assessments continue to rely on hormonal assays and pelvic sonography. Although the adnexal or tubal ring sign is a diagnostic feature of ectopic pregnancy on pelvic sonography, it has not been well recognized on computed tomography (CT) due to radiation concerns. However, CT is increasingly being used in emergency situations where the patient’s medical history is unknown or unavailable. Further, it can be unintentionally performed on a pregnant patient. The aim of this retrospective study is to determine the diagnostic value of the adnexal ring sign on contrast-enhanced CT.

In this review, we included 877 cases of pathologically proven ectopic pregnancy recorded between January 2003 and December 2012, among which 14 underwent abdominal CT before surgery. Next, the images and surgical findings were retrospectively analyzed to assess the correlation between the adnexal ring sign on CT and the presence of ectopic pregnancy.

The adnexal ring sign was positive in 11 of 14 surgically proven ectopic pregnancies. The sensitivity and specificity of the adnexal ring sign under CT scan were calculated as 78.6% and 92.3%, respectively, and the positive and negative predictive values were 91.7% and 80.0%, respectively. The likelihood ratio (sensitivity / [1−specificity]) was 10.2.

In conclusion, our study supports the contention that the CT adnexal ring sign correlates with the presence of ectopic pregnancy. The presence of CT adnexal ring sign with hemoperitoneum and an increase in human chorionic gonadotropin should strongly suggest the diagnosis of ruptured ectopic pregnancy.

Keywords: ectopic pregnancy, CT, adnexal ring sign, diagnosis

INTRODUCTION

Ectopic pregnancy is not a rare condition, accounting for approximately 2% of all reported pregnancies and 9% of all pregnancy-related deaths [1]. Risk factors include any history of ectopic pregnancy, gynecologic operation, pelvic inflammatory disease, use of intrauterine device, infertility, in vitro fertilization, placenta previa, congenital uterine anomalies, endometriosis, smoking, and exposure to diethylstilbestrol [1, 2].

Currently, the primary imaging modality for evaluating ectopic pregnancy is ultrasound, and an adnexal ring sign is considered diagnostic. Given that, in general, pregnant women should not receive computed tomography (CT), the imaging features of ectopic pregnancy via this modality are not well established. However, in many emergency or
traumatic conditions where the pregnancy status of the patient is unknown, CT may be the most readily available tool to assess an acute abdomen. Although the adnexal ring of ectopic pregnancy on contrast-enhanced CT has previously been described, our knowledge of its usefulness is still limited. In this study, we try to determine the diagnostic value of the adnexal ring sign on CT in ectopic pregnancy.

MATERIALS AND METHODS

Study Design
In this retrospective study, we included all patients with pathologically proven ectopic pregnancy treated at our institution between January 2003 and December 2012. Any patient who underwent a CT before surgical intervention was included, and we compared adnexal images on CT with the corresponding surgical findings. We collected data on age, confirmed diagnosis of ectopic pregnancy, and the presence or absence of rupture. In addition, we recorded whether pregnancy tests were performed, whether these were positive by urine or blood test, the trimester, and whether hemoperitoneum was noted on CT and at surgery.

CT Examination
CT examinations were performed on a PQ 5000 (Picker international, Inc., Cleveland, Ohio, USA) single-slice CT or, more recently, a Sensation 16-slice MDCT scanner (Siemens AG, Medical Solutions, Erlangen, Germany). For both CT procedures, we administered 80–100 mL of iodinated intravenous contrast material at a rate of 1.5–2 ml/s. In the single helical CT, axial images were obtained with a reconstruction interval of 8 mm and a pitch of 1.5; and, in the 16-slice multi-section CT, we obtained axial images at 2-mm thicknesses and 1.7-mm interval, with additional coronal reconstructed images of the abdomen obtained as necessary.

The CT images were independently reviewed by two radiologists with no prior knowledge of the surgical findings. If there was a disagreement in the findings, the two reviewers reached consensus through discussion.

Outcome Measures
We evaluated the correlation between the adnexal ring sign on CT and a confirmed diagnosis of ectopic pregnancy. In assessing the bilateral adnexa, the adnexal ring sign was considered positive when it was significantly enhanced and complete through at least 270 degrees; otherwise, it was defined as negative. These image findings were then compared with the surgical results and pathological diagnosis.

Statistical Analysis
We calculated the sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and likely ratio to assess the correlation between the

Figure 1

Figure 1. A 39-year-old woman with a ruptured ectopic pregnancy. 

a. Axial computed tomography showed a ring-like structure with intense enhancement in the right adnexa (arrows). Hyperdense fluid in the peritoneum was consistent with hemoperitoneum (arrowheads). 

b. Ultrasound showed a gestation sac with a thick echogenic rim outside the uterus (thick arrows).
adnexal ring sign on CT and the presence of ectopic pregnancy. The likelihood ratio was calculated as sensitivity / [1−specificity].

RESULTS

Participants and Descriptive Data

During the study period, 877 cases of pathologically proven ectopic pregnancy were recorded at our institution. Of these, 14 cases had CT performed before surgical intervention. The 14 participants were aged 19 to 43 years, and all were confirmed cases of ectopic pregnancy and rupture. One patient had undergone a unilateral salpingectomy because of ectopic pregnancy in the past, so we collected 27 images of adnexa (13 pairs and 1 side) to compare with surgical findings. Table 1 lists the emergency indications for CT in these 14 women.

According to medical records, pregnancy tests were performed in 13 patients, of whom 10 tested positive by urine or blood pregnancy test, and the remaining three were negative only by urine test. Ruptured ectopic pregnancy occurred in all patients: nine during the first trimester and five during the second trimester.

CT Findings

Hemoperitoneum was noted in all patients on CT scan and confirmed at surgery. In addition, the adnexal ring sign was positive in 11 adnexa (Fig. 1) and negative in 3 out of 14 (Fig. 2, 3b) pathologically proven ectopic pregnancies. In one adnexitis, the adnexal ring sign was positive, but surgery did not reveal an ectopic pregnancy (Fig. 3a).

Diagnostic Accuracy of CT for Ectopic Pregnancy

Table 2 summarizes the correlation between CT findings and pathological diagnosis. The sensitivity and specificity of the adnexal ring sign on CT scan were 78.6% and 92.3%, respectively. The PPV and NPV were 91.7% and 80.0%, respectively. The likelihood ratio was calculated as 10.2.

DISCUSSION

Ectopic pregnancy is the primary cause of death in the first trimester of pregnancy, leading to rupture and severe bleeding at the site of pregnancy. Approximately 95%
of ectopic pregnancies occur in the fallopian tube, with the most common site being the ampulla followed by the isthmus [1]. Ectopic pregnancy should always be considered in women of child-bearing age who present with the classic triad of abdominal or pelvic pain, vaginal spotting, and a tender adnexal mass [1, 2].

The initial assessment of ectopic pregnancy is performed by pelvic sonography and quantitative analysis of serum human chorionic gonadotropin (β-hCG) [3-5]. The most common and predictive sonographic finding, occurring in 68% to 78% of ectopic pregnancies [6, 7], is the tubal ring sign. This represented a thick-walled adnexal cyst, indicating the extrauterine gestational sac surrounded by trophoblastic tissue. Color Doppler ultrasound can reveal an additional “ring of fire” sign that demonstrates the peripheral hypervascularity around the chorionic sac. Ectopic tubal pregnancy is strongly suggested when the echogenic adnexal ring is found apart from the ovary in a patient with a serum β-hCG above the discriminatory level, and with no visible evidence of intrauterine gestation [3, 4]. However, sonography has some disadvantages in diagnosis, not least of which are its limited resolution and limited field of view, particularly when used in irritated or obese patients.

Based on a literature review, experiences with using CT for the evaluation of ectopic pregnancy are limited because pregnant patients generally do not undergo CT examination. In recent years, CT has become a more widely used modality for assessing patients following trauma or for assessing the differential diagnosis of acute abdomens. In other situations, it is possible that a CT scan could be performed accidentally on a pregnant patient. These include when patients have an intrauterine device inserted, are unaware or in denial of pregnancy, or have a chronic ectopic pregnancy with a β-hCG below the discriminatory level [8].

Only a limited number of case reports have described the CT findings of ruptured tubal pregnancy. The reported findings include the presence of a dramatically enhanced adnexal ring with hemoperitoneum, which corresponds to the ring of fire sign revealed by color Doppler sonography [9, 10]. Indeed, this could be most diagnostic of ectopic pregnancy on CT imaging. Our retrospective study of CT images from 14 patients showed that the adnexal ring sign did correlate with the presence of ectopic pregnancy. Statistical analysis shows that the CT ring sign has a specificity of 92.3%, a PPV of 91.7%, and a likelihood ratio of 10.2, implying the sign to be considerably promising and specific for the presence of ectopic pregnancy.

Other conditions can, of course, mimic the adnexal ring sign on CT. The most likely condition is a corpus luteal cyst [11-14], which caused the false positive case in

Figure 3

3a

Figure 3. A 40-year-old women with a history of right lower abdominal pain. Ectopic pregnancy of the right adnexa with active bleeding was confirmed. a. Contrast-enhanced axial computed tomography before operation demonstrated the adnexal ring sign on the left side (arrows), which was proved to be a corpus luteal cyst. b. A coronal section in the same patient revealed contrast extravasation on the right side without a complete adnexal ring (arrowheads).
Image observation of ectopic pregnancy on CT

our study (Fig. 3a). The true cause of a corpus luteal cyst rupture is not fully understood, but it has been suggested that increased vascularity of the ovary during the luteal phase may lead to cyst rupture [15]. Accurate differentiation between the two conditions by CT alone is challenging, but it has been proposed that β-hCG could be a distinctive indicator. Thus, a positive β-hCG in the presence of an adnexal ring sign indicates ectopic pregnancy, whereas a negative result might suggest a corpus luteal cyst [16].

Other etiologies with peripheral enhancement that resemble the adnexal ring sign on CT include tubo-ovarian abscess and cystic ovarian neoplasm. Pham and Lin [10] have reported that the degree of peripheral enhancement of the adnexal mass in tubal pregnancy appears to be substantially greater than that in tubo-ovarian abscess and cystic ovarian neoplasm. In addition, clinical features of infection are often evident in cases of tubo-ovarian abscess [17, 18], while ovarian neoplasm rarely causes hemoperitoneum. These features and signs should help clinicians when assessing the differential diagnosis.

Despite the practical usefulness of the adnexal ring sign on CT, it is not an infallible indicator. An incomplete, inadequate, or inactive ring of trophoblastic tissue surrounding the chorionic sac could jeopardize visualization of the ring on CT. Indeed, these features might explain the three false negative cases in our study. In one of these cases, tubal pregnancy was proven in the isthmic portion of the fallopian tube, which is the narrowest and least distensible portion that is more likely to rupture early in the course of pregnancy (Fig. 2). The other two cases presented with either an incomplete ring or a poorly defined complex adnexal mass with active contrast medium extravasation and hemoperitoneum (Fig. 3b). It is possible that the CT adnexal ring sign might be masked during rupture, especially in the early stage of pregnancy, which could obscure the adnexal ring on CT.

This study has some important limitations. First, we did not include patients with corpus luteal cyst rupture in the study population, so could not compare the specificity of the adnexal ring sign between ectopic pregnancy and corpus luteal cyst rupture. Therefore, we focused on the statistical significance of the sign within our ectopic pregnancy population. Second, because the study was retrospective, we could not confirm that optimal views for demonstrating adnexal ring were obtained in every case. Third, CT examinations were performed on different scanners, which could have introduced bias in determining the presence or absence of adnexal rings because only our more recent MDCT scanner had isotropic imaging. Fourth, quantitative blood tests were not available to confirm pregnancy before operation in all our cases. Finally, the small sample size also makes it difficult to draw strong conclusions.

In conclusion, our study supports the contention that the CT adnexal ring sign correlates with the presence of ectopic pregnancy. The presence of CT adnexal ring sign with hemoperitoneum and an increase in human chorionic gonadotropin should strongly suggest the diagnosis of ruptured ectopic pregnancy.

ACKNOWLEDGEMENT

We thank Dr. Alan Kwok-Kuen Pang for his guidance in conducting this study.

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