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Magnetic resonance imaging of tubal ectopic pregnancy: correlation with intraoperative findings

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ABSTRACT

Ectopic pregnancy is defined as a pregnancy that occurs outside of the uterine cavity (ACOG Committee on Practice Bulletins, 2018 [1]). Ectopic pregnancy is occasionally diagnosed with MRI. Particularly, when ultrasound is nondiagnostic, it is essential that radiologists are able to recognize findings of ectopic pregnancy on MRI in the emergent setting. This novel case report demonstrates specific MR imaging signs recently proposed in the literature to help identify a tubal gestational sac, the most common type of ectopic pregnancy, and is the first reported case demonstrating intraoperative correlation with MRI findings of tubal ectopic pregnancy.

1. Introduction

Ectopic pregnancy is defined as a pregnancy that occurs outside of the uterine cavity [1]. Ectopic pregnancy is occasionally diagnosed with MRI. Particularly, when ultrasound is nondiagnostic, it is essential that radiologists are able to recognize findings of ectopic pregnancy on MRI in the emergent setting. This novel case report demonstrates specific MR imaging signs recently proposed in the literature to help identify a tubal gestational sac, the most common type of ectopic pregnancy, and is the first reported case demonstrating intraoperative correlation with MRI findings of tubal ectopic pregnancy.

2. Clinical case

A 33 year old G1P0 female presented to the emergency department with vaginal bleeding and lower abdominal cramping for 3 days. She reported that her periods had been irregular but increasing in frequency 1 month prior to presentation, with a large amount of vaginal bleeding noted 1 week prior to presentation. 5 days prior to presentation she developed abdominal cramping. On the day of presentation she took two home pregnancy tests that were positive. Laboratory testing demonstrated a beta-HCG level of 5580. The on-call obstetrics-gynecology resident was consulted and performed a pelvic ultrasound, which demonstrated a large heterogeneous left adnexal mass of uncertain etiology (Fig. 1). No intrauterine gestational sac or free fluid was identified.

The patient demonstrated vital signs within normal limits and was otherwise clinically stable. Because of the finding of a left adnexal mass on a limited quality pelvic ultrasound, the unavailability of a certified ultrasound technician for more detailed evaluation overnight, the patient's desire for pregnancy, the patient's stable clinical status, and to minimize risk from operating without a complete diagnostic picture, emergent pelvic MRI was requested for further evaluation.

3. Materials and methods

MRI was performed on a GE Optima 450w utilizing a 1.5 Tesla magnet. Routine female pelvis MRI protocol was performed without the administration of intravenous contrast, including 3 plane T2 weighted sequences, axial T1-weighted sequence with fat subtraction, axial T1 in and opposed phase images, and axial DWI sequence with ADC map. These sequences are further detailed as follows.

Three plane T2 weighted sequences consisted of an axial T2 weighted sequence (TR 9700 ms, TE 117 ms), coronal T2 weighted sequence (TR 7250 ms, TE 110 ms), and a sagittal T2 weighted sequence with fat saturation (TR 3525 ms, TE 112 ms). Axial T1-weighted sequences included an axial T1 pre contrast 3D sequence with fat saturation (T6 6.3 ms, TE 3.1 ms) as well as T1 axial in-phase and out-of-phase sequences (TR 6.3 ms, TE 4.2 ms and 2.1 ms respectively). Axial DWI and ADC maps were performed with TR 9680 ms, TE 61.6 ms, and with b values of 50, 400, and 800 s/mm^2.

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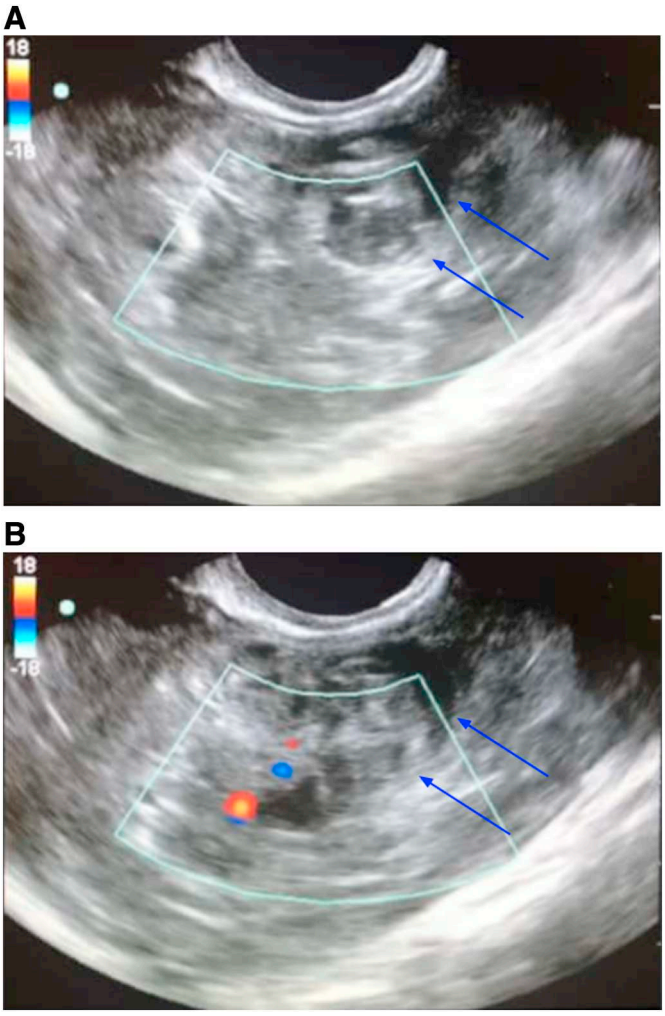

Fig. 1. A and B: Transvaginal ultrasound images demonstrated a heterogeneous mass within the left adnexa, of uncertain etiology (blue arrows). No gestational sac was identified within this adnexal mass. No intrauterine pregnancy or free fluid was identified. Because of the finding of a left adnexal mass on a limited quality pelvic ultrasound, the patient's desire for pregnancy, the patient's stable clinical status, and to minimize risk from operating without a complete diagnostic picture, emergent pelvic MRI was requested for further evaluation. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

4. MRI findings

A left adnexal mass with heterogeneous T2 weighted signal was identified on MRI, separate from the left ovary which appeared normal (Fig. 2). Left hematosalpinx was demonstrated, along with hemoperitoneum centered in the left pelvis (Fig. 3). No intrauterine gestational sac was identified, and the uterine endometrium was normal thickness. Further analysis of the images demonstrated MR findings suggestive of a gestational sac within the ampullary region of the left fallopian tube (Figs. 4 and 5). Findings were reported as suspicious for left ectopic pregnancy with associated tubal rupture.

5. Surgical and pathological correlation

During laparoscopy (Fig. 6), approximately 600 ml of blood was noted in the pelvis with a large clot noted at the fimbriated end of a dilated left fallopian tube. Suction was used to remove blood and clear the fallopian tube of blood products. Left salpingectomy was performed and the resected left fallopian tube was sent for pathologic analysis.

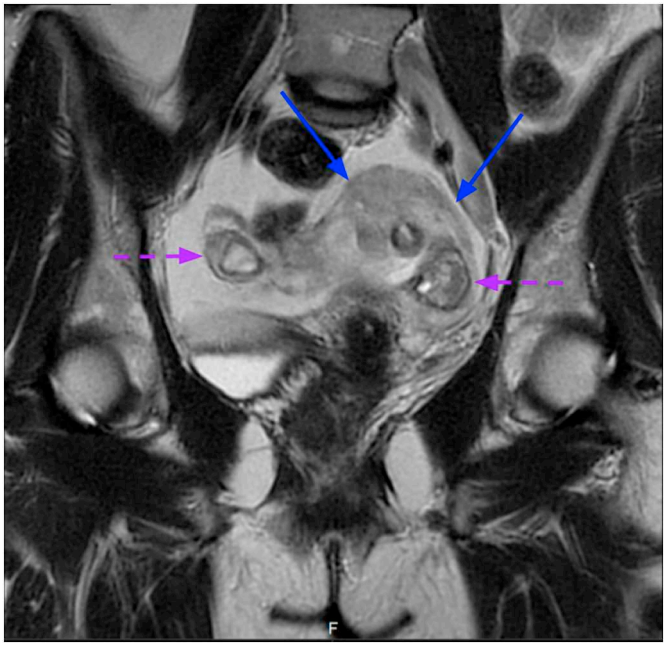

Fig. 2. Coronal T2 weighted imaging demonstrated a left adnexal mass with heterogeneous T2 weighted signal (solid blue arrows) separate from the left ovary, which appeared normal. The ovaries are annotated with purple dashed arrows. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

The submitted specimen consisted of a tan-pink, tubular soft tissue fragment measuring 4.5 cm in length and 1.1 cm in diameter. Serial sectioning revealed a lumen filled with tan-pink to tan-red material corresponding to chorionic villi, along with hemorrhagic material. No fetal parts were grossly visible. In the container received there were also multiple fragments of pink-tan hemorrhagic tissue and blood clot, measuring 6.5 × 4.5 × 1.6 cm in aggregate. Histologic analysis of the dilated fallopian tube identified intraluminal hemorrhage, chorionic villi, a gestational sac, and extravillous trophoblasts (Fig. 7). The pathologic diagnosis was made as left ectopic tubal pregnancy with associated hemorrhage of the fallopian tube.

6. Discussion

Based on aggregated data from the National Hospital Discharge Survey and the National Hospital Ambulatory Medical Care Survey, the rate of ectopic pregnancies in 1992 was 19.7 per 1000 reported pregnancies [2]. In 2011–2013, ruptured ectopic pregnancy accounted for 2.7% of all pregnancy-related deaths [3]. Clinical presentation factors associated with a significant increase in adjusted odds ratio for ectopic pregnancy include: history of prior ectopic pregnancy (2.98 for one prior), moderate to severe bleeding at presentation (1.42), and pain as presenting symptom (1.42) [4]. Our patient presented to the emergency room with pain and vaginal bleeding.

The fallopian tube is the most common location of ectopic implantation, accounting for more than 90% of cases, and the most common sites of ectopic pregnancy are ampullary (70.0%), followed by isthmic (12.0%), fimbrial (11.1%), ovarian (3.2%), interstitial (2.4%),

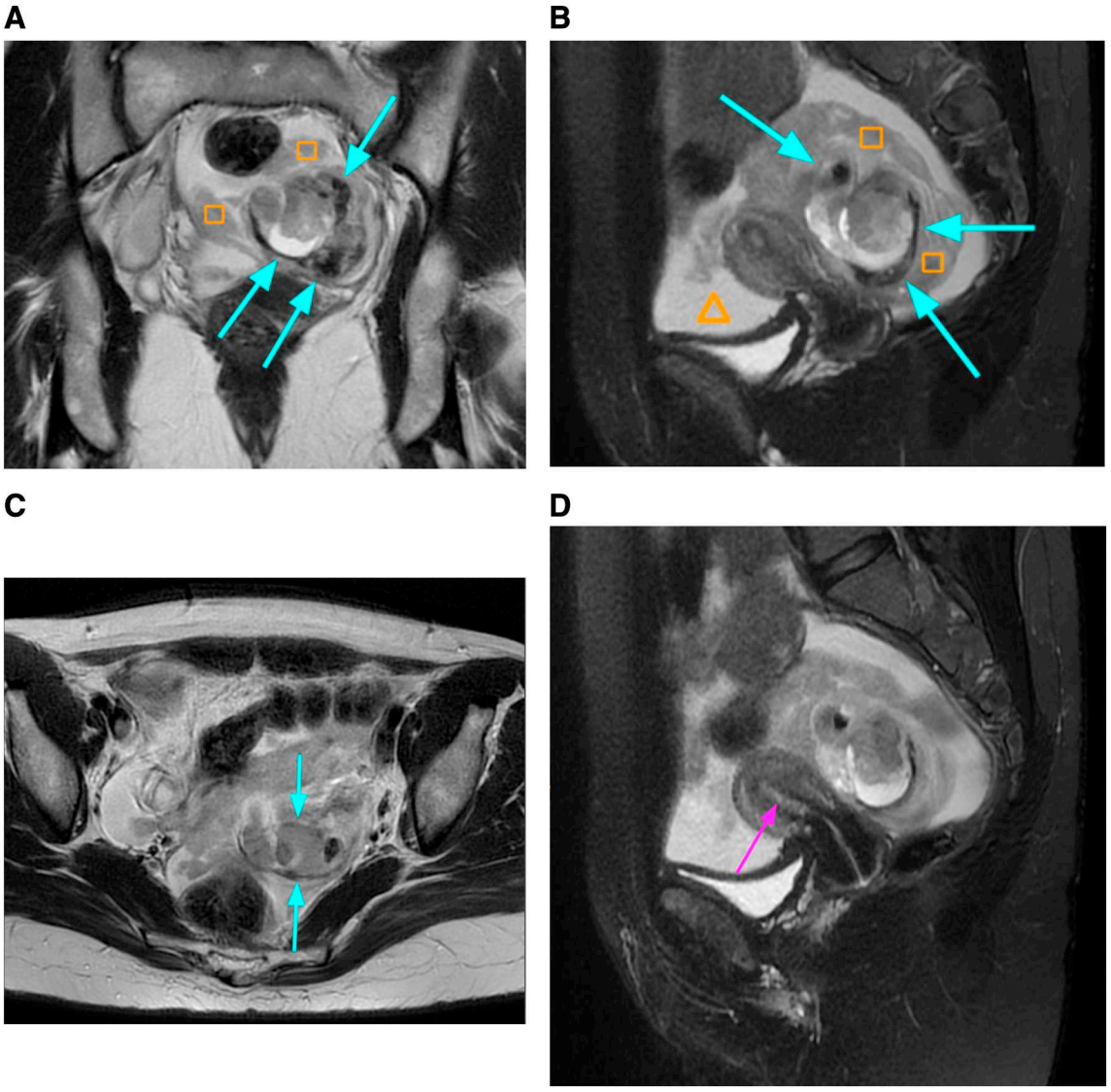

Fig. 3. T2 weighted coronal (Fig. 3A), sagittal (B, D), and axial (C) images demonstrated a dilated tubular structure containing mixed T2 signal blood products, representing left hematosalpinx. Clumped T2 hypointensities surrounding the tube (orange open squares), as well as more homogenously diffuse T2 hypointense fluid within the pelvis (orange open triangle) represented hemoperitoneum concentrated in proximity to the left fallopian tube. There was normal thickness of the uterine endometrium without an intrauterine gestation sac (D, magenta arrow). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

and abdominal (1.3%) [5]. This case demonstrated a gestational-sac like structure in the ampullary segment of the left fallopian tube.

As per 2018 ACOG Practice Guidelines on Tubal Ectopic Pregnancy [1] (Table 1), our patient had a beta-HCG level appropriately elevated to initiate diagnostic workup for ectopic pregnancy. Diagnostic evaluation consisted of transvaginal ultrasound prior to pelvic MRI, which demonstrated an inconclusive left adnexal mass. As per 2011 consensus statement by Barnhart et al. [6], an inhomogeneous adnexal mass without definite gestational sac is classified as a "probable ectopic pregnancy," as opposed to when an extrauterine gestational sac is observed, which is classified as a "definite ectopic pregnancy." Obtaining pelvic MRI allowed more definitive characterization of the suspected left ectopic pregnancy, excluding other left adnexal masses such as dermoid cyst from the differential diagnosis. While rare, there are reports of adnexal masses other than ectopic pregnancy in the setting of a positive pregnancy test and no visible intrauterine pregnancy on ultrasound [7,8]. The MRI also showed hemoperitoneum, which was not visualized on the pelvic ultrasound and is an indication for emergent surgery as per 2018 ACOG Practice Guidelines because it suggests tubal rupture. In this case, hemoperitoneum was due to hemorrhage through the fimbriated end of the fallopian tube. Performing emergent MRI proved to be a prudent decision in this clinical situation, allowing more specific confirmation of the diagnosis of ectopic pregnancy in a clinically stable patient who desired pregnancy, and allowing salpingectomy to be performed expediently before the fallopian tube had reached the point of gross rupture, minimizing technical difficulty of the surgery.

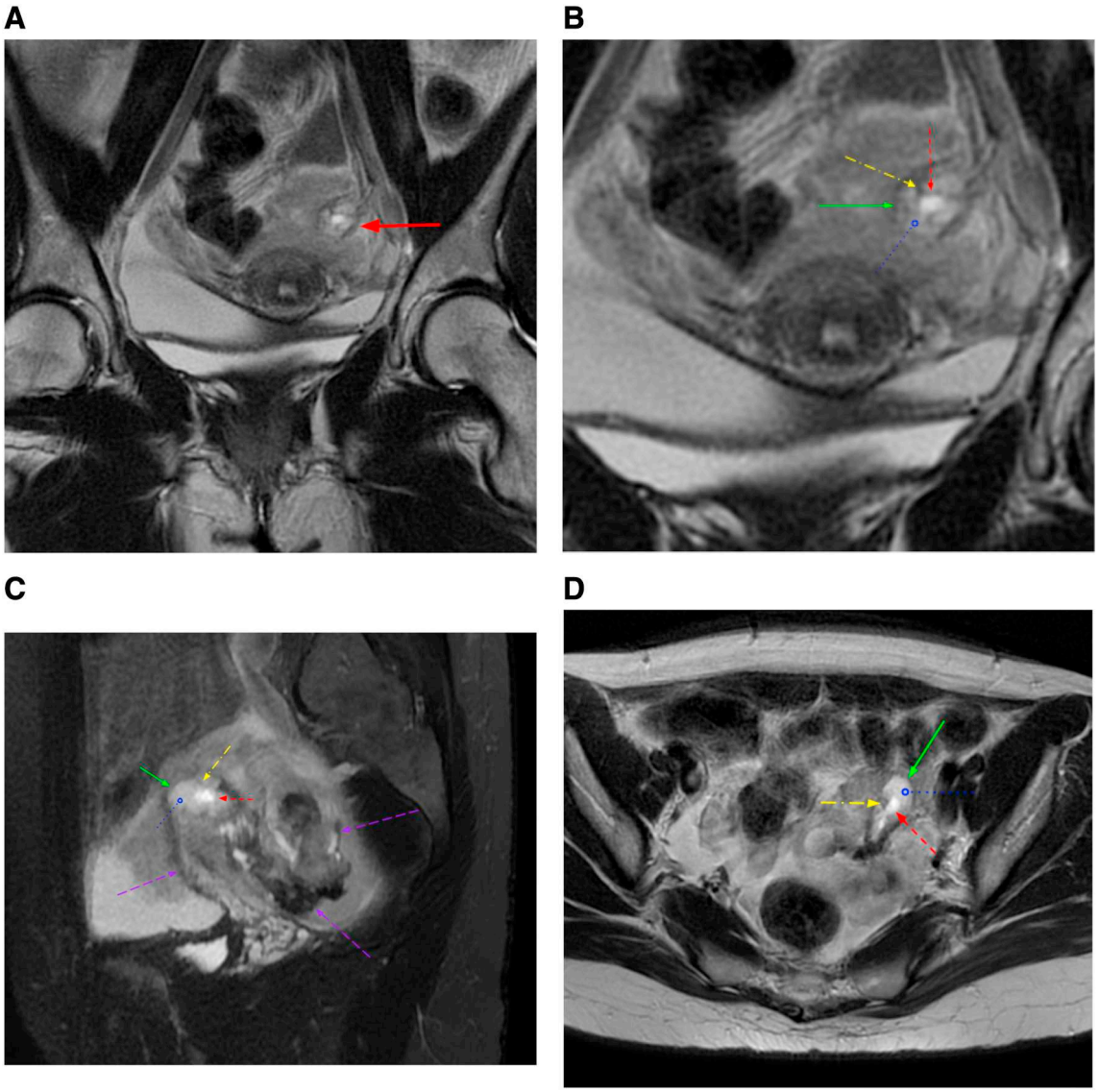

Fig. 4. Coronal T2 weighted image (Fig. 4A) demonstrated the gestational sac (solid red arrow) within the left adnexal region. Fig. 4B is a zoomed and further annotated image of 4A demonstrating the "three-ring sign" (hypointense outer wall-hyperintense middle wall-iso/hypointense inner wall) [9], respectively noted by the solid green arrow, dotted blue arrow with open circle arrowhead, and red short-dashed arrow. The yellow dash-dot arrow annotates dot-like or low linear areas of low T2 signal represent small vessels within the gestational sac [9]. T2 weighted sagittal (C) and axial (D) images of the gestational sac have also been notated in the above manner. Note the gestational sac's location in the ampullary region (C) of the dilated fallopian tube containing blood products (purple long-dashed arrows). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

The patient was discharged home several hours after the procedure without complication.

This clinical vignette illustrates that when performing emergent ultrasound for ectopic pregnancy, it would be useful to include transabdominal imaging in order to assess the paracolic gutters, perihepatic, and perisplenic regions to further evaluate for the presence and quantity of hemoperitoneum [9]. Transvaginal ultrasound examination may not be sufficiently sensitive for detection of hemoperitoneum as in this presented scenario. However, ultrasound image quality and availability may be limited due to technical factors such as operator dependency, bowel gas, and body habitus, and radiologists should be prepared to make this diagnosis on MRI in the emergent setting as ectopic pregnancy cannot be excluded with ultrasound in a number of cases [10].

The utility of MRI in the diagnosis of ectopic pregnancy was explored by Takahashi et al. in a retrospective review where 26 consecutive patients clinically suspected of having an ectopic pregnancy were identified; all had underwent indeterminate transvaginal ultrasound examination before MRI [11]. The sensitivity of MRI for identifying an extrauterine gestational sac, adnexal hematoma, hemorrhagic ascites, and tubal dilatation was 91.3%, 50%, 46%, and 33.3%, respectively, with specificity of 100% for all mentioned direct and indirect findings of ectopic pregnancy [11]. In our patient, all of these findings were observed on MRI (Figs. 2, 3, and 4).

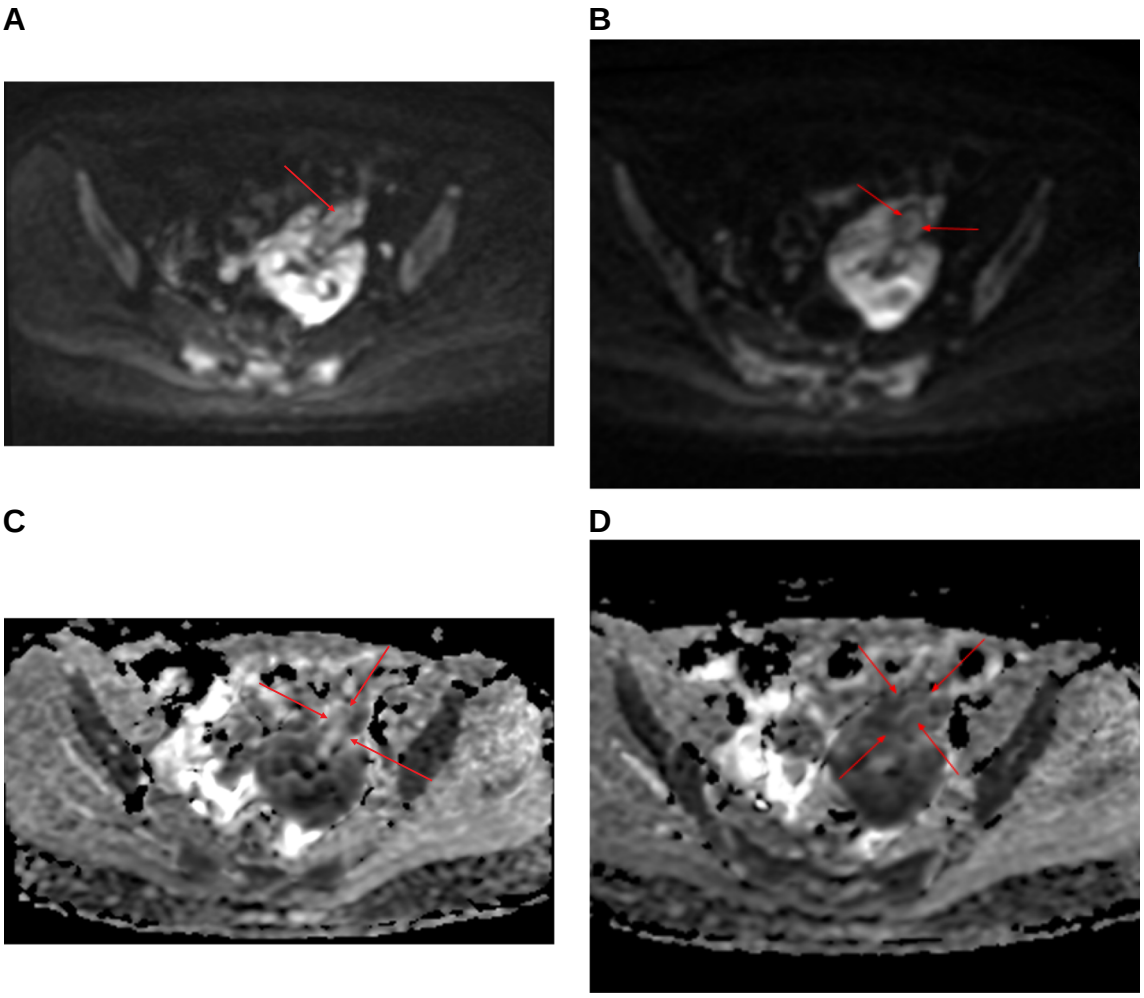

Fig. 5. Axial DWI images (Fig. 5A and B) demonstrated an area of restricted diffusion within the wall of the gestational sac, confirmed on the axial ADC maps (C and D). This is the "ring of restriction" sign [10].

This case report demonstrates the "three-ring sign" as described by Si et al. [12] on T2 weighted images, which consists of a hypointense outer ring, hyperintense middle ring, and hypointense to isointense inner ring. According to pathologic analysis, the thin outer ring is formed by the adjacent tubal wall, while the thin inner ring is formed by extraembryonic coelom and amnion without blood vessels [12]. The thick middle ring is composed of chorionic villi tissue, which contains abundant fetal capillaries and maternal blood in the interstitium [12]. Si et al. reviewed 27 cases of tubal ectopic pregnancy and also demonstrated that the size of the gestational sac-like structure was essentially unchanged over varying estimated gestational ages of 4–8 weeks, measuring between 13 and 43 (25 ± 8) mm, suggesting a delay in gestational sac growth due to abnormal implantation [12] and minimal change in size over early pregnancy. The estimated gestational age of the ectopic pregnancy was unknown in our case, but the size was within one standard deviation of the mean from Si et al.'s paper, measuring 18.6 mm. Very few other adnexal structures will demonstrate this consistent size and appearance, allowing one to confidently make the diagnosis in the appropriate clinical scenario (i.e. positive pregnancy test).

Diffusion-weighted imaging has also been utilized in MR imaging of ectopic pregnancy. A "ring of restriction sign [13]" can be seen in the wall of the gestational sac, which is thought to be secondary to the high cellularity and rate of proliferation of trophoblasts, vascular-fibroblastic proliferation, and macromolecules within the cytoplasm and extracellular matrix. Restricted diffusion was seen in the wall of the ectopic gestational sac in this case as well.

T1 weighted imaging can improve detection of hemorrhage in the setting of ectopic pregnancy. Fat-suppressed T1-weighted images are also useful in the differentiation of blood products from macroscopic fat, such as the bulk fat seen in a germ cell tumor such as dermoid cyst [14]. Contrast-enhanced imaging may help detect tubal rupture. Signs of tubal rupture include disruption of tubal wall enhancement and the presence of acute hematoma, as shown by hemorrhage located outside the implantation site on T1 and T2-weighted images [15]. However, if there is a possibility of intrauterine gestation, gadolinium contrast agents should be avoided [14]. In this case, the diagnosis was primarily made using T2 weighted sequences and diffusion weighted imaging, and no IV contrast was administered. Of note, the findings of hemoperitoneum and left hematosalpinx in our patient were poorly

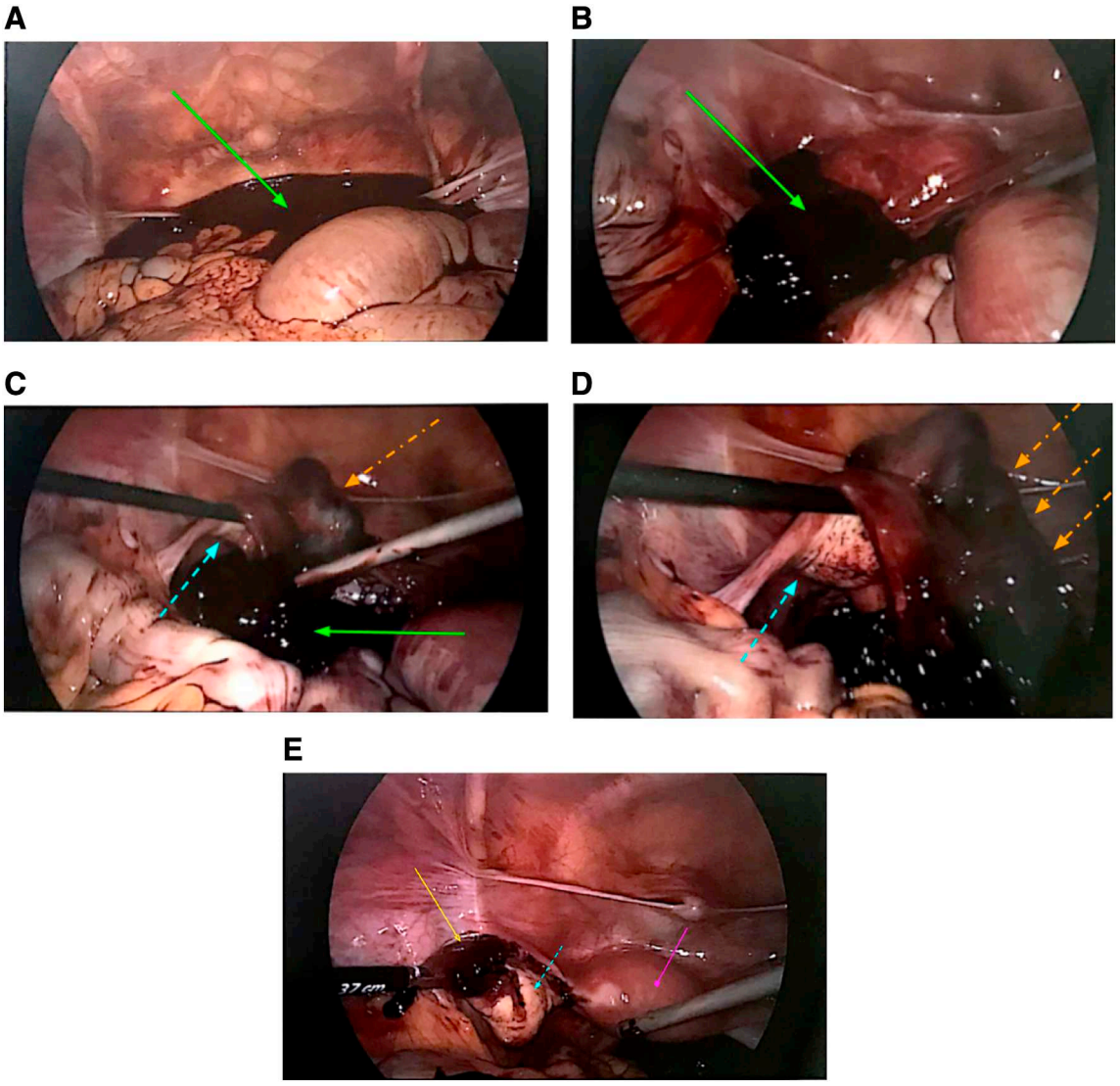

Fig. 6. Intraoperative photographs from left laparoscopic salpingectomy are shown in Fig. 6A–E. Fig. 6A, B, and C demonstrate hemoperitoneum (solid green arrows) within the deep pelvis upon initial surgical exploration. 6C and D show the left ovary (dashed cyan arrows) at its attachment with the left ovarian ligament. The left fallopian tube (orange dash-dot arrows) is dilated, twisted, and demonstrates abnormal dark red-purple color. Fig. 6E demonstrates the left adnexa after left salpingectomy. The pink square arrowhead denotes the uterus. A large blood clot is noted at the fimbriated end of the left fallopian tube (yellow open arrowhead), presumably where hemorrhage from the left fallopian tube had been spilling into the peritoneum as there was no gross rupture of the left fallopian tube observed. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

visualized on T1 pre-contrast 3D fat saturation and T1 in- and out-of-phase sequences (perhaps due to the acuity of the blood products, rendering them isointense on T1 weighted imaging).

7. Conclusion

This case is unique for several reasons. Ectopic pregnancy is rarely seen by radiologists on MRI, yet is essential to diagnose correctly in the emergency setting. In situations where emergent diagnostic obstetric ultrasound is limited due to technical difficulty of the case, MRI may be requested, and this paper illustrates the appearance of tubal ectopic pregnancy on MRI and characteristics that distinguish ectopic pregnancy from other potential adnexal masses. In addition, this report reviews and independently replicates findings suggested by prior authors' studies (i.e. “three-ring sign [12]” and “ring of restriction [13]”), and is the first report to present the two signs together in a case. These findings help increase the specificity of the radiologist in diagnosing an adnexal mass in the setting of a positive pregnancy test as a tubal ectopic pregnancy. It is also the first report to present detailed intraoperative photographs correlating with MRI findings suggesting tubal ectopic pregnancy, representing an invaluable learning opportunity for radiologists. Improved recognition of the signs of tubal ectopic pregnancy among radiologists responsible for interpreting studies from the emergency department will improve diagnostic accuracy and patient care.

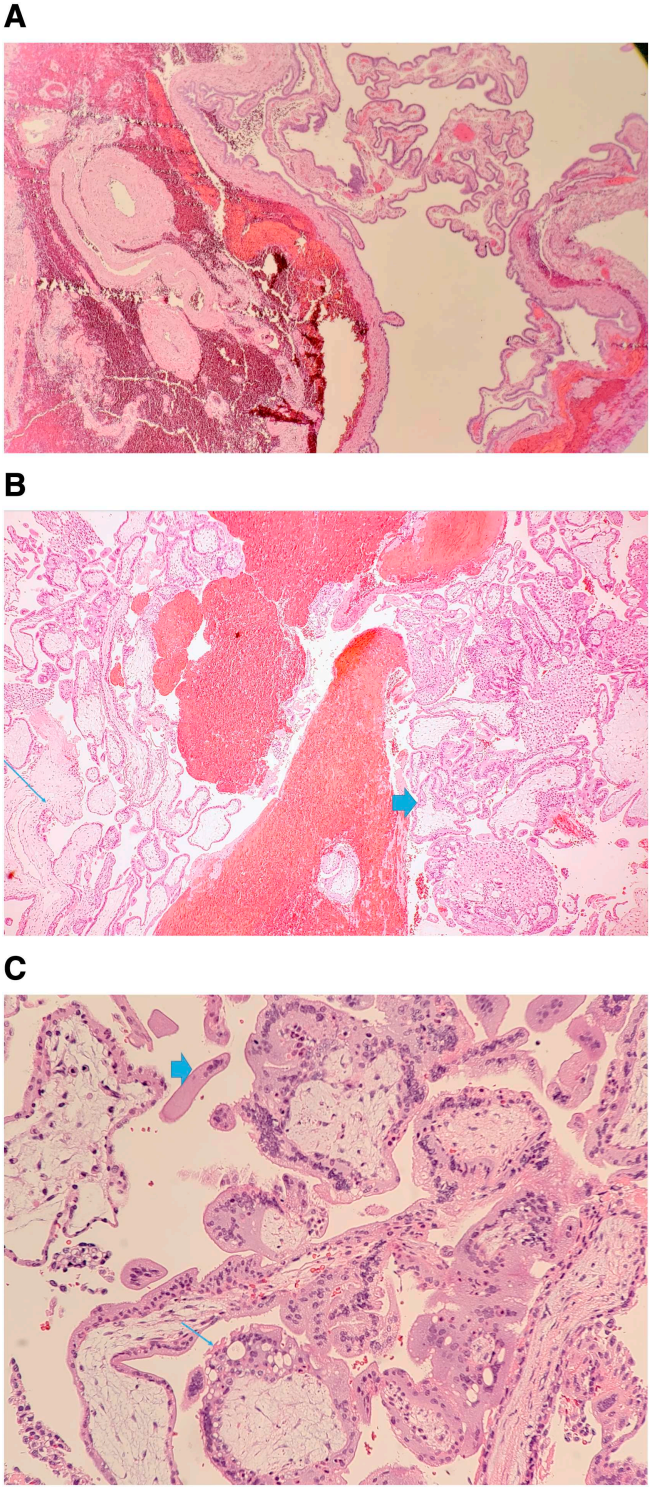

Fig. 7. A Representative cross section from the enlarged fallopian tube showing hemorrhagic salpingitis (100 X magnification).
B 200 X magnification. Tubal pregnancy is evident by presence of intraluminal chorionic villi (one is indicated by short thick arrow), gestational sac (indicated by long thin arrow on left), and blood clot (central).
C 400 X magnification. Chorionic villi (indicated by thin arrow at bottom of image) and extravillous trophoblasts (indicated by thick arrow) are present within the fallopian tube lumen.

Table 1
Selected 2018 ACOG Practice Guidelines on Tubal Ectopic Pregnancy [1] related to this clinical vignette.

Selected 2018 ACOG Practice Guidelines on Tubal Ectopic Pregnancy [1]
Surgical management of ectopic pregnancy is required when a patient is exhibiting any of the following: hemodynamic instability, symptoms of an ongoing ruptured ectopic mass (such as pelvic pain), or signs of intraperitoneal bleeding. (Level A)
If the concept of the hCG discriminatory level is to be used as a diagnostic aid in women at risk of ectopic pregnancy, the value should be conservatively high (e.g., as high as 3500 mIU/mL) to avoid the potential for misdiagnosis and possible interruption of an intrauterine pregnancy that a woman hopes to continue. (Level B)
The decision to perform a salpingostomy or salpingectomy for the treatment of ectopic pregnancy should be guided by the patient's clinical status, her desire for future fertility, and the extent of fallopian tube damage. (Level B)
The minimum diagnostic evaluation of a suspected ectopic pregnancy is a transvaginal ultrasound evaluation and confirmation of pregnancy. Serial evaluation with transvaginal ultrasonography, or serum hCG level measurement, or both, often is required to confirm the diagnosis. (Level C)

Declaration of competing interest

None.

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