Pictorial Essay

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MR Imaging for Ectopic Pregnancy

자궁 외 임신에 대한 자기공명영상 소견

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Ectopic pregnancy (EP) is diagnosed based on laboratory values and ultrasonography (US) findings. Evaluation for suspected EP should begin with a quantitative measurement of the serum β-human chorionic gonadotropin levels and transvaginal US. MR imaging is not preferentially performed in the evaluation of EP; however, if the findings of transvaginal US are uncertain, MR imaging can be used, as it has the advantages of superior soft-tissue contrast resolution and a wide scanning range. Identifying the exact location of implantation transfer using MR imaging can help in the diagnosis and establishment of treatment strategies for ectopic pregnancies, including laparoscopy. In particular, as the incidence of heterotopic pregnancy has increased with the recent increase in use of assisted reproductive technology, the scope of application of MR imaging is expected to expand further. This pictorial essay describes the various manifestations of EP and related conditions on MR imaging and US. Familiarity with the clinical setting and the US and MR imaging features of EP and associated conditions can lead to a more accurate diagnosis and treatment.

Index terms Ectopic Pregnancy; Heterotopic Pregnancy; Magnetic Resonance Imaging; Ultrasonography

INTRODUCTION

Ectopic pregnancy (EP) is defined as an atypical blastocyst implantation outside the uterine endometrium. EPs are most frequently found in the fallopian tube, particularly in the ampullary portion. Other possible locations for EP are the myometrium, ovary, cesarean section scar, uterine cervix, and abdominal cavity; however, these are rare. EPs account for approximately 2% of all pregnancies. Although the associated mortality rate has decreased significantly, EP remains the prevailing cause of mortality during the first trimester of pregnancy (1).

CLINICAL FEATURES

The major risk factors associated with EP include a history of EP, pelvic inflammatory disease, and gynecologic surgery. Other identified risk factors include the use of intrauterine contraceptive devices, in vivo fertilization, and documented tubal disease (1). As the proportion of infertile couples has increased worldwide, the demand for in vitro fertilization and embryo transfer has increased dramatically, leading to an increase in the incidence of EP. The causes of EP after fertility treatment can be the effects of the treatment itself or a preexisting disorder (2). The traditional triage of EP symptoms consists of a palpable adnexal mass, vaginal bleeding, and pain. However, this triad only occurs in some patients with EP (approximately 45%) and can manifest in other conditions, including normal early pregnancy, abortion, and gestational trophoblastic disease. In addition, common medical entities seen in young women that are not related to pregnancy, such as hemorrhagic ovarian cysts, ovarian torsion, cholecystitis, and kidney stones, may also present with similar symptoms. Therefore, a differential diagnosis based on symptoms alone is challenging (3). The natural history of EP occurs in several ways. Although spontaneous resolution can occur, rupture may occur if the tumor size increases; if it persists, it may progress to a state of chronic EP (1).

DIAGNOSIS OF EP

SERUM β-HUMAN CHORIONIC GONADOTROPIN (β-hCG)

Human chorionic gonadotropin (hCG) is a glycoprotein hormone, and the subtype β-hCG increases in a curvilinear manner at the beginning of pregnancy (4). Serum β-hCG is a more sensitive indicator for pregnancy, compared with urine β-hCG (3). In pregnancy, serum β-hCG levels ascend until a gestational age (GA) of 9–11 weeks and reach a plateau of 100000 mIU/mL. After a few days of remaining at the plateau level, β-hCG levels start declining at a GA of around 20 weeks (1, 4). In a typical pregnancy, the average doubling time of β-hCG is 2 days (48 h) (5). β-hCG can be detected using radioimmunoassay 9 days after conception and approximately 23 days after the last menstrual period (LMP) (3).

In women with an intrauterine pregnancy (IUP), the β-hCG levels remain at a minimum of 2000 mIU/mL. Hence, this value is considered the discriminatory level of β-hCG at which a normal IUP can be confirmed by transvaginal ultrasonography (US) (3). When there is no evidence of IUP in a patient with a β-hCG level exceeding 2000 mIU/mL and surpassing the expected visible period based on the LMP, the potential diagnoses of very early IUP, pregnancy failure, and EP must be considered. These conditions are referred to as pregnancies occurring at unknown locations. The patient should undergo close monitoring through serial US examinations and repeated β-hCG level checks until an EP or an IUP is determined (1, 3).

US FOR EP DIAGNOSIS

US is the imaging modality of choice for EP (1). Specific US findings of EP include decidual cysts, pseudosacs, live embryos, tubal rings, ring-of-fire signs, tubal masses, and hemoperitoneum.

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ENDOMETRIAL FINDINGS

A "decidual cyst" refers to a well-defined cystic structure typically located at the junction of the endometrium and the myometrium. It is a small fluid collection typical of EP and lacks an echogenic rim (Fig. 1). However, they can also be present in patients with normal early IUP (5). Thus, it can be present in both the IUP and the EP. A central collection of fluid in the endometrial cavity is called a pseudosac. The key features of pseudosacs include heterogeneous echogenicity due to internal blood and debris, mid-cavity location of the endometrium, and the presence of only a single layer corresponding to the endometrial decidual reaction (Fig. 2) (3, 5, 6).

ADNEXAL FINDINGS

The most specific and pathognomonic finding of EP is a live extrauterine embryo; however, this sign is uncommon (Fig. 3) (3, 5). The second most specific sign is the presence of an extrauterine gestational sac (GS) containing a yolk sac with or without an embryo. However, a hemorrhagic cyst must not be mistaken for debris that mimics the yolk sac or embryo (5). A more common adnexal finding in EP, although slightly less specific, is the tubal ring. The tubal ring sign refers to an extrauterine mass with a fluid center and a thick echogenic wall that should

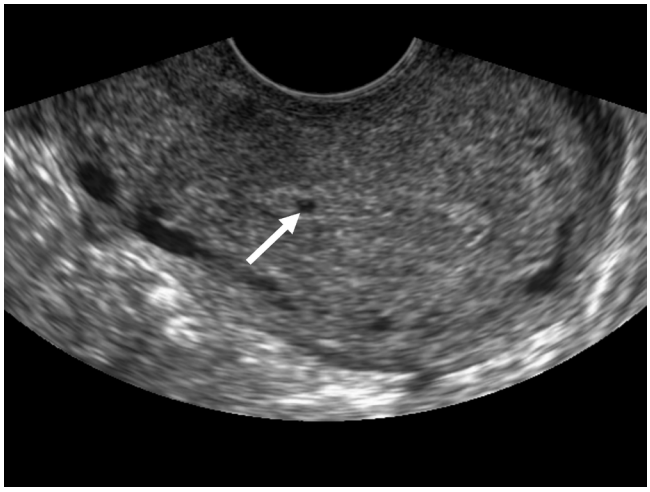


Fig. 1. US feature of ectopic pregnancy: decidual cyst.
The sagittal transvaginal view of the uterus shows a small fluid collection at the junction of the endometrium and myometrium (arrow).

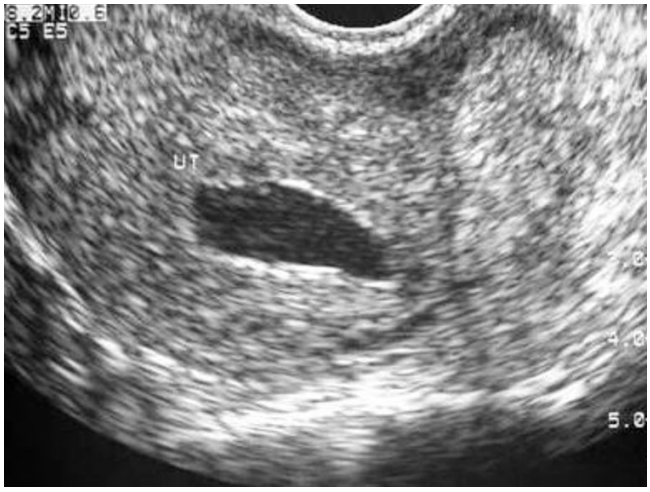


Fig. 2. US feature of ectopic pregnancy: pseudosac.
A sagittal transvaginal scan of the uterus shows a small, centrally located fluid collection with internal blood and debris in the endometrial cavity.

Fig. 3. US feature of ectopic pregnancy: live extrauterine embryo.
A, B. Transvaginal view with m-mode shows embryo (calipers) with normal cardiac activity (arrows).

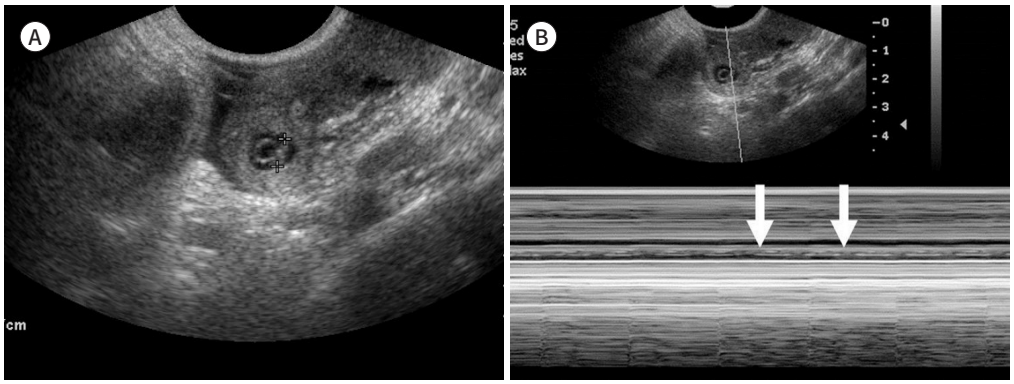
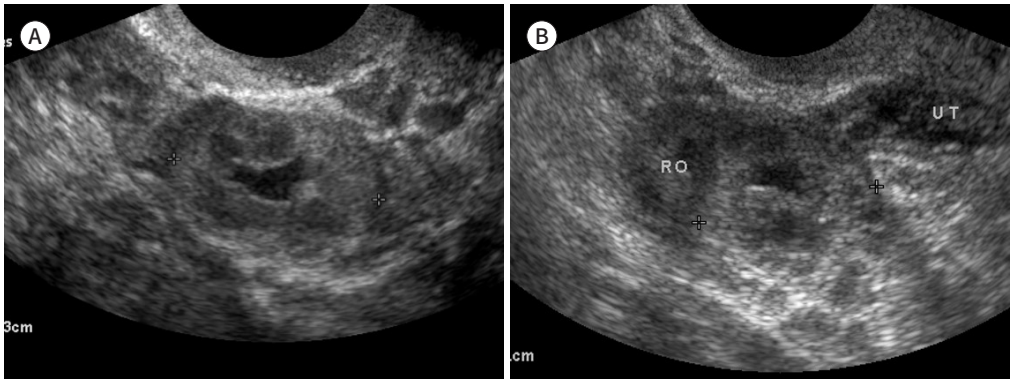


Fig. 4. US feature of ectopic pregnancy: tubal ring sign.
A, B. Transvaginal view of the uterus and right ovary shows an extrauterine mass (calipers) with thick echogenic wall. Note that the mass moves separately from the ovary.



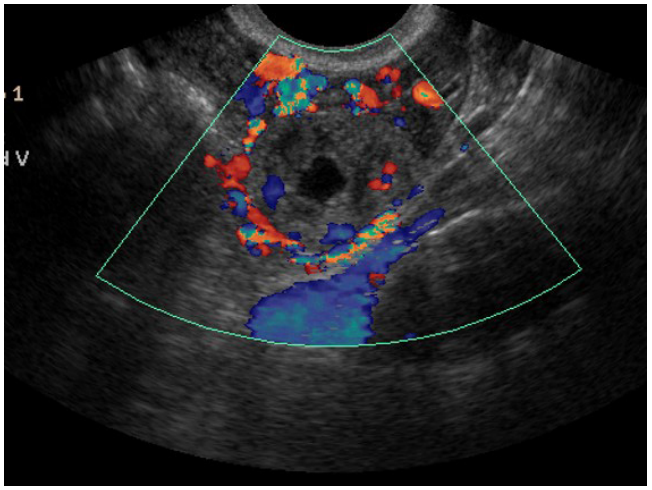


Fig. 5. US feature of EP: the "ring-of-fire" sign.
Color Doppler US shows increased blood flow around an EP.
EP = ectopic pregnancy

be differentiated from a corpus luteum cyst (Fig. 4) (1). A related finding is the "ring of fire," which refers to the flow around an EP on color Doppler US (Fig. 5). This is because of the low impedance and high diastolic flow surrounding the tubal ring. However, this phenomenon is a nonspecific finding more likely to be visualized in the corpus luteum than in the EP (3). Tubal pregnancy may also appear as a nonspecific mass with heterogeneous echogenicity and

without an identifiable GS (Fig. 6). This is the least specific but the most common sonographic finding in patients with EP (3, 5).

PELVIC FINDINGS

A hypoechoic finding or mixed echogenicity indicates hemoperitoneum and becomes more hyperechoic as blood clots organize. Floating echoes or a layered appearance within the fluid indicates hemoperitoneum, which may be a sign of EP. They typically accumulate in gravity-dependent areas, most commonly in the cul-de-sac. Fluid collection at the pericolic gutters and pouch of Morrison can also indicate hemoperitoneum (Fig. 7) (3, 6).

MR IMAGING FOR EP

US is the first-line imaging modality for evaluating abdominal pain in pregnant women. However, if the US results are inconclusive or if further data are needed, additional diagnostic imaging may be required. CT is an undesirable imaging tool because of concerns regarding the safety of prenatal radiation. In this case, MR imaging can be a helpful problem-solving tool (7, 8). In pregnant women, gadolinium (Gd) should be used cautiously and only when

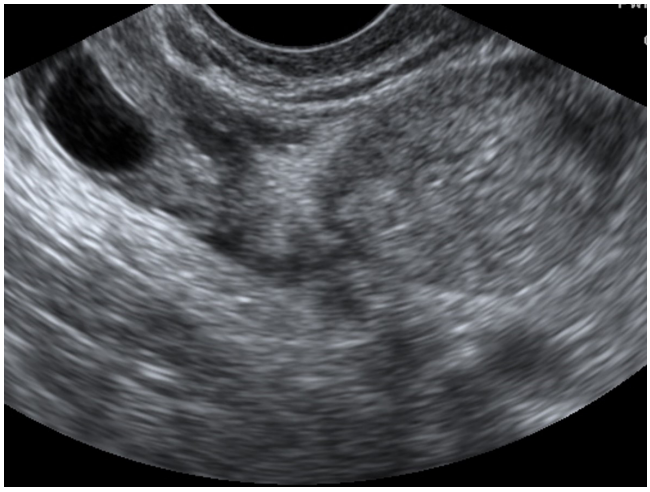


Fig. 6. US feature of ectopic pregnancy: tubal mass.
Transvaginal scan shows a nonspecific mass with heterogeneous echogenicity.

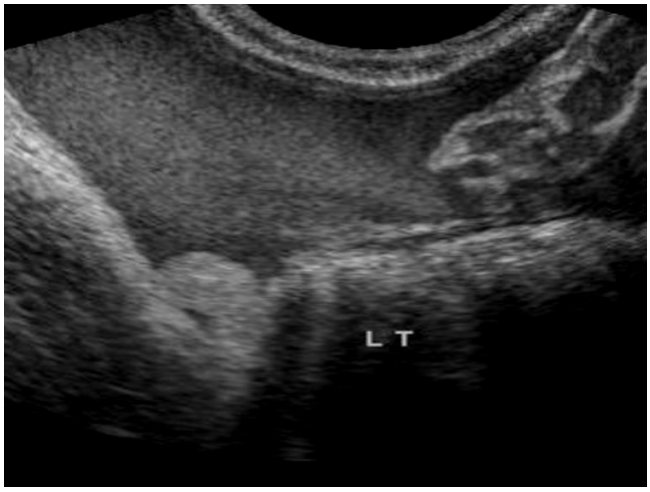


Fig. 7. US feature of ectopic pregnancy: hemoperitoneum.
Transabdominal view of the pelvis shows large amount of free fluid with mixed echogenicity.

necessary, and its potential benefits should be justified. Gd is not recommended to be used during the first trimester of pregnancy (9). Without using radiation or intravenous contrast agents, MR imaging can produce images with strong soft-tissue contrast in multiple planes. MR imaging provides a precise assessment of the lesion and is essential for early identification of EP when it cannot be diagnosed using US, thereby aiding decision-making (7, 8, 10). If MR imaging is performed suitably in hemodynamically and clinically stable patients, various information on EP can be obtained (11). It can localize the implant site more accurately and show detailed pelvic anatomy, including the fallopian tubes, round ligaments, and adnexal structures (12).

Specific MR imaging findings of EP include the absence of an IUP, an adnexal mass distinct from the ovary, and hemoperitoneum (10).

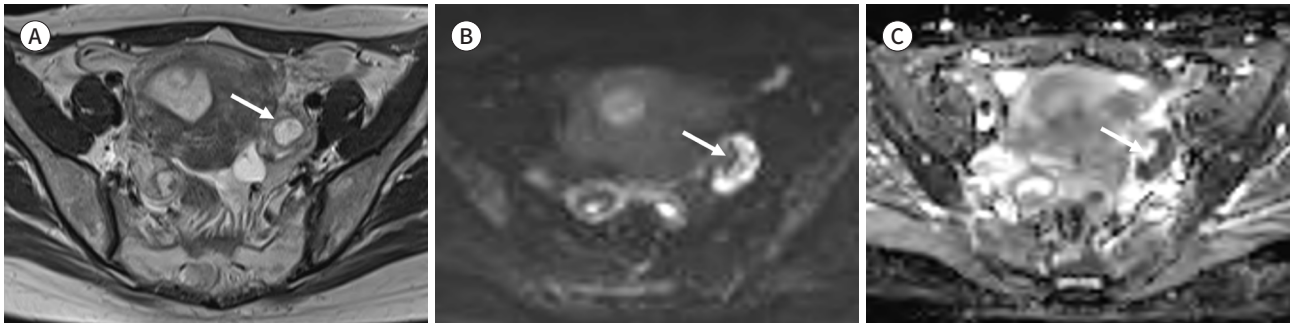
EXTRAUTERINE GS

Extrauterine GS is the most specific finding of EP on MR imaging, similar to that observed on US (12). On T1-weighted imaging (T1WI), GS is typically observed as a thick-walled cystic mass. On T2-weighted imaging (T2WI), the thick wall typically shows three layered rings, which is known as the "three-ring sign" (Fig. 8A). The thin inner ring consists of the extraembryonic coelom and amnion without blood vessels and is therefore hypointense on T2WI. The interstitium of the thick middle ring, which is composed of chorionic villus tissues, is home to numerous fetal capillaries and maternal blood. Hence, it appears hyperintense on T2WI and shows marked enhancement. The thin outer ring, which appears hypointense on T2WI, is formed by the adjacent tubal wall (10).

Conversely, the wall of the GS shows diffusion restrictions on diffusion-weighted imaging (DWI) and apparent diffusion coefficient (ADC) maps (Fig. 8B, C). These characteristics can be related to cellular possessions, vascular fibroblastic proliferation, macromolecules within the cytoplasm, and the extracellular matrix. It is similar to the "ring of fire" on US (Fig. 5). Therefore, DWI and ADC maps can be valuable in distinguishing EP from other cystic lesions (13).

In large GSs, solid components composed of embryonic tissues can be detected using MR imaging (10).

Fig. 8. MR imaging findings in a 40-year-old woman with ectopic pregnancy.
A. Transverse T2-weighted imaging shows a thick-walled cyst (arrow), indicating extrauterine gestational sac and a "three-ring sign."
B, C. Diffusion-weighted imaging (B) and apparent diffusion coefficient map (C) show a "ring-of-restriction" sign (arrows).



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CHANGES IN THE FALLOPIAN TUBE

Changes in the affected fallopian tube can also be used to identify EP. Dilatation of the fallopian tube with hematosalpinx and tubal wall enhancement has been observed (10). Following implantation of the ovum into the epithelium of the fallopian tube, chorionic villi and trophoblasts invade the tubal wall, forming the placenta. During this process, maternal vessels often rupture into the GS, leading to the formation of a tubal hematoma (hematosalpinx) (Fig. 9) (7).

HEMOPERITONEUM

Isolated bloody ascites have been reported to be a crucial indicator of EP. Acute to subacute blood appears as isointense to hyperintense fluid on T1WI and as a heterogeneous signal intensity (SI) on T2WI (Figs. 9-11) (7, 10).

MR IMAGING OF EP-RELATED CONDITIONS

PREGNANCY OF UNKNOWN LOCATION (PUL)

PUL refers to a transient state defined by a positive β-hCG test without evidence of either an IUP or an EP on transvaginal US (14). The possible causes of PUL include early normal IUP, pregnancy failure, or EP (6). In such situations, MR imaging can be used an additional imaging tool for the diagnosis.

HETEROTOPIC PREGNANCY

Heterotopic pregnancy refers to the simultaneous coexistence of normal IUP and EP (Figs. 10, 11). It can be either spontaneous or the result of assisted conception. Although this condition occurs spontaneously in 1 in 30000 pregnancies, its prevalence increases in women who conceive through assisted reproduction, to 1 in 1000 (15). The importance of heterotopic pregnancies is increasing as women undergo assisted reproduction, particularly ovulation induction.

Fig. 9. MR imaging findings in a 42-year-old woman with chronic pelvic pain for 1 year and low level of β-human chorionic gonadotropin elevation.
A-C. Transverse T2WI (A), transverse contrast-enhanced-T1WI (B), and coronal T2WI (C) show a heterogeneous mass in the pelvis. The combined left tubal dilatation and enhancement are shown. A few chorionic villi in a hemorrhagic background at the left adnexa are consistent with ectopic gestation.
WI = weighted imaging

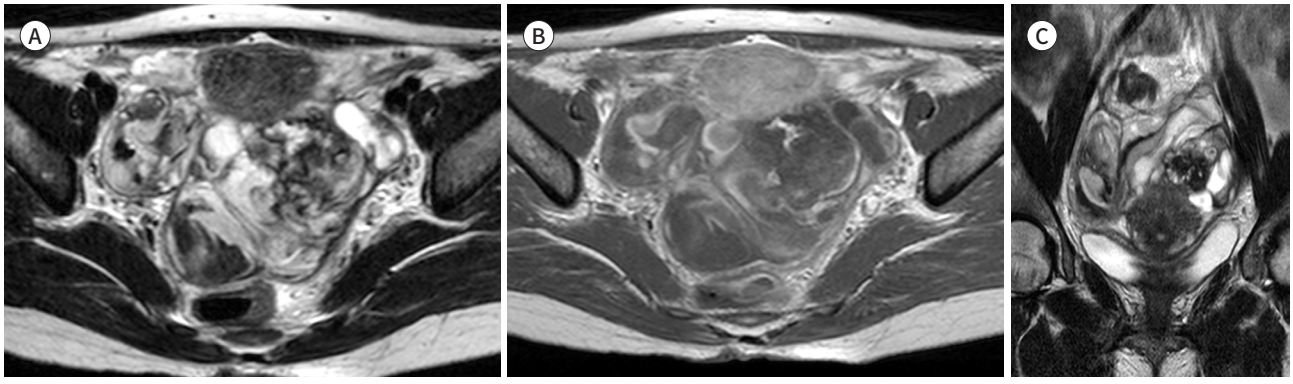
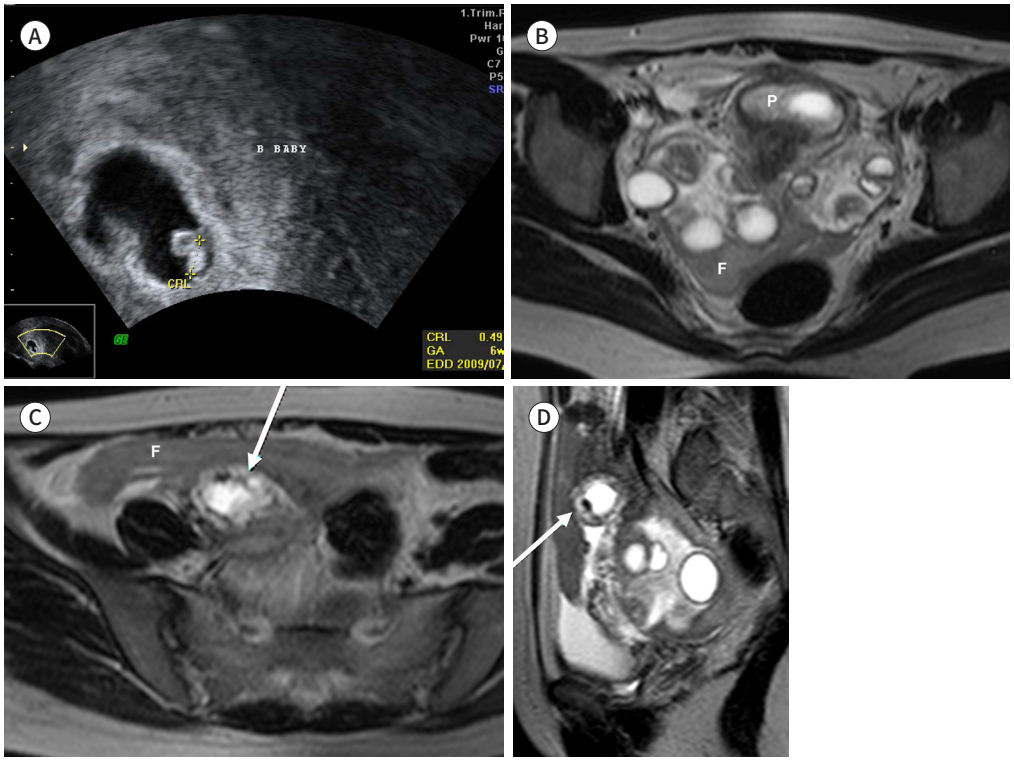


Fig. 10. MR imaging findings in a 32-year-old woman with sudden abdominal pain due to heterotopic pregnancy. She had undergone in vitro fertilization and embryo transfer and had a twin pregnancy (gestational age: 7 weeks).
A. Transvaginal sonogram shows normal IUP (calipers).
B. Transverse T2WI shows IUP (P) and small hemoperitoneum (F).
C, D. Transverse (C) and sagittal (D) T2WI show right-sided ectopic pregnancy (arrows) and small hemoperitoneum (F).
IUP = intrauterine pregnancy, WI = weighted imaging



Pelvic pain in a patient with assisted reproduction should be considered when ruling out heterotopic pregnancy, which remains a diagnostic problem (1). MR imaging is a highly effective modality for detecting intrauterine and extrauterine pregnancies. However, indications for MR imaging should be determined with caution if IUP maintenance is desired (16).

CHRONIC EP

Chronic EP refers to a type of tubal pregnancy in which silent minor ruptures or abortions of the EP occur instead of a single episode of bleeding (17). Prolonged mild hemorrhage during EP results in hematoma formation, which induces an inflammatory reaction, adhesions, and formation of a complex pelvic mass (Fig. 9). The clinical features are mild, and the symptoms are subtle. In cases of chronic EP, few chorionic villi produce β-hCG during chronic EP, which explains a low serum β-hCG or negative urine pregnancy test (17).

In a sexually active woman of reproductive age, the presence of an adnexal mass with positive β-hCG indicates an EP until proven otherwise. However, outside pregnancy, β-hCG can also be produced by neoplastic, even malignant germ cells, placental, or embryonal tissues. These include germ cell tumors, gestational trophoblastic diseases, teratomas, and testicular

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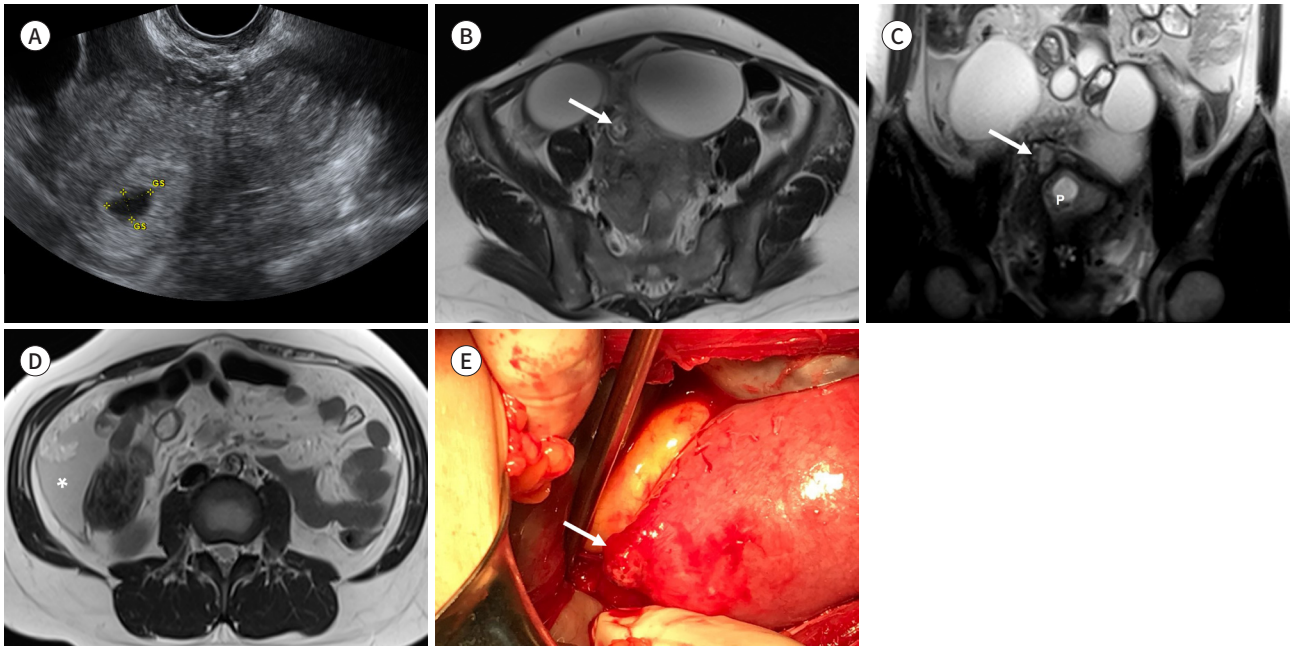
Fig. 11. MR imaging findings in a 27-year-old woman with right lower quadrant pain for 1 day.
A. Transvaginal US demonstrates an intrauterine GS.
B-D. Transverse and coronal T2-weighted imaging show an endometrial GS (P) and another GS (arrows) in the right interstitium of the uterus, suggesting interstitial and heterotopic pregnancy. A large amount of hemoperitoneum (*) at the right paracolic gutter is evident. MR imaging can detect EP and intrauterine pregnancy.
E. Laparoscopy shows an EP (arrow) in the right interstitium of the uterus with active bleeding. Hemoperitoneum in the pelvis to the upper liver dome is also evident.
EP = ectopic pregnancy, GS = gestational sac



cancers. Thus, in the presence of an adnexal mass, careful evaluation of patients and considering the possibility of neoplasms that can be a source of β-hCG production are important. Although 50% of EPs are asymptomatic, abdominal pain resulting from distention, hemorrhage, or necrosis is a common symptom of most malignant germ cell tumors (18). Therefore, gynecological cancer and EP may be distinguished by comprehensively considering the presence or absence of symptoms such as abdominal pain, tumor markers, and further imaging (17).

UNUSUALLY LOCATED EP

INTERSTITIAL PREGNANCY

CLINICAL FEATURES

Interstitial pregnancy involves implantation at the most proximal part of the fallopian tube and intramyometrial segments (1, 7, 16). Compared with tubal pregnancies, these pregnancies have higher rates of morbidity and mortality (5). This high morbidity is associated with the fact that the interstitial portion of the fallopian tube is elastic; therefore, it dilates more freely and painlessly than the rest of the tube. This results in a delayed clinical presentation, compared with typical EP, and the possibility of life-threatening massive hemorrhage (5, 11).

IMAGING FEATURES

When an IUP is observed at a high location in the uterine fundus and is not entirely surrounded by a 5-mm thick myometrium in all planes, a diagnosis of interstitial pregnancy is suggested (Fig. 11) (5). On MR imaging, a heterogeneous GS-like structure located just lateral to the cornua and surrounded by myometrium strongly indicates interstitial pregnancy. This is represented by a high T2 SI (Fig. 11) (7, 16).

CERVICAL PREGNANCY

CLINICAL FEATURES

A rare type of EP, called cervical pregnancy, occurs when the embryo is implanted in the cervical mucosa below the level of the internal cervical opening (11). It accounts for less than 1% of all EPs and is associated with in vitro fertilization and previous curettage (1). This condition may clinically mimic ongoing spontaneous abortion, incomplete abortion, gestational trophoblastic disease, cesarean section pregnancy, or low-lying placenta (12).

IMAGING FEATURES

As the fetus grows within the cervix, the uterus may show an "hourglass" or "figure-of-eight-like" appearance (1). Furthermore, live embryos with cardiac activity or GS with peritrophoblastic flow below the internal cervical opening strongly indicate a cervical pregnancy (1, 5). Cervical pregnancy can be visualized on MR imaging as a lobulated mass with heterogeneous SI and a partial or complete dark rim on T2WI (11, 12). Contrast-enhanced imaging reveals an irregular peripheral rim enhancement and densely enhanced papillary components. Mixed-stage hemorrhage is a probable cause of heterogeneous SI, and enhanced papillary components indicate retained products of the fetoplacental tissues (11, 16).

SCAR PREGNANCY

CLINICAL FEATURES

Cesarean scar pregnancy refers to implantation at the site of a previous cesarean delivery incision, leading to the formation of a GS surrounded by myometrial and fibrous tissue (11, 16). A plausible explanation is that a conduit links the uterine myometrium and endometrial canal, enabling implantation inside the scar (1). Cesarean scar pregnancy is rare (less than 1% of all pregnancies); however, its incidence increases with the rate of cesarean section deliveries (11, 12).

IMAGING FEATURES

On US, the GS, located on the anterior wall of the inferior part of the uterus, can be visualized. The myometrium may also be thinned anteriorly owing to compression by the GS (1). MR imaging findings include an empty uterus/cervical canal, a GS-like structure in the anterior part of the lower uterine segment, and the location of a prior cesarean section. A markedly thin myometrium can be observed between the GS and bladder wall (12, 16).

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OVARIAN PREGNANCY

CLINICAL FEATURES

Ovarian pregnancy refers to the implantation of a fertilized ovum in the ovary. It comprises up to 3% of all EPs. Ovarian pregnancies are significantly associated with the use of intrauterine devices (11). In this condition, the challenge is distinguishing ovarian EP from functional ovarian cysts, such as corpus luteum or hemorrhagic cysts.

IMAGING FEATURES

Ovarian pregnancies typically present with ovarian cysts characterized by thick echogenic peripheral vascular rings (5, 19). Ovarian pregnancy is associated with the presence of GS, chorionic villi, or an aberrant cyst within the ovary with a hyperechoic ring, as well as normal fallopian tubes (1, 5).

On MR imaging, ovarian pregnancy can be observed as a GS-like structure, either on or inside the ovary, often containing an acute hematoma with low SI on T2WI (11). Additionally, they show thickened, irregular walls with heterogeneous enhancement (12, 16).

ABDOMINAL PREGNANCY

CLINICAL FEATURES

The definition of abdominal pregnancy (1.3% of all EPs) is the implantation of a GS outside the uterus, fallopian tubes, and ovaries within the peritoneal cavity (12). Pregnancy commonly occurs in the anterior and posterior uterine pouches, uterus, and adnexal serosa (12). Because pregnancy can potentially advance GA, it is associated with high morbidity and

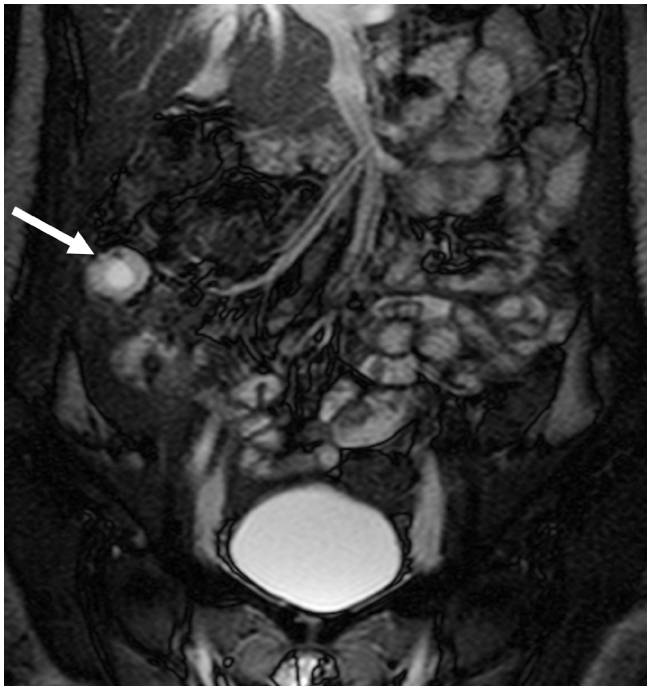

Fig. 12. MR imaging finding in a 28-year-old woman with abdominal EP. Coronal T2-weighted imaging shows a well-defined cystic lesion with a thick peripheral wall (arrow) in the lateral aspect of the ascending colon, suggested to be the focus of the EP. Adapted from Kim et al. *Abdom Radiol (NY)* 2022;47:2254-2276, with permission of Springer Nature (20).
EP = ectopic pregnancy

Table 1. MR Imaging of Ectopic Pregnancy

	MR Features
Extrauterine gestational sac	Thick-walled cystic mass on T1WI
	"3-ring sign" on T2WI; three layered wall of inner hypo – middle hyper – outer hypo SI
	Diffusion restriction (+)
	Solid components (±) in large gestational sac
Changes in fallopian tube	Dilatation of fallopian tube
	Tubal hematoma (hemosalphinx)
	Tubal wall enhancement
Hemoperitoneum	Collects in gravity-dependent areas, most commonly in the cul-de-sac
	Iso- to hyper SI on T1WI
	Heterogeneous SI on T2WI

SI = signal intensity, WI = weighted imaging

mortality due to delayed detection and usually requires surgical treatment (16).

IMAGING FEATURES

Typical US findings in an abdominal pregnancy include an empty uterus and no myometrial tissue between the maternal bladder and the pregnancy (11).

The findings of abdominal EP on MR imaging include the presence of a GS outside the reproductive tract (Fig. 12), which may or may not show hemorrhage. For example, it has been found in the pouch of Douglas. An important finding is the absence of myometrium surrounding the sac. These findings are best observed on T2WI (7, 12, 20). Peritoneal enhancement surrounding the sac can also be observed (16).

CONCLUSION

MR imaging is a useful problem-solving imaging tool for diagnosing EP and systematically evaluates the entire abdomen (Tables 1, 2).

Radiologists should be comfortable diagnosing EP on MR imaging, particularly when US findings are equivocal or inconclusive. Familiarity with both US and MR imaging features of EP and related conditions and making a comprehensive interpretation considering the clinical setting can facilitate a more accurate diagnosis with prompt and appropriate treatment.

Author Contributions

Conceptualization, P.S.B.; data curation, H.J.J., P.S.B.; investigation, H.J.J.; supervision, P.S.B.; validation, P.S.B.; writing—original draft, H.J.J., P.S.B.; and writing—review & editing, all authors.

Conflicts of Interest

The authors have no potential conflicts of interest to disclose.

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Table 2. MR Imaging of EP-Related Conditions

	Clinical Features	Imaging Features
Pregnancy of unknown location	Positive β-hCG test without evidence of either IUP or EP Possible causes: early, normal IUP, early pregnancy failure and EP	
Heterotopic pregnancy	Either spontaneous or the result of assisted conception Increasing prevalence with increased assisted reproduction	Coexistence of normal IUP and EP
Chronic EP	Silent minor ruptures or abortions of an EP Asymptomatic or subtle symptom Low serum β-hCG or negative urine pregnancy test	Tubal hematoma or complex pelvic mass
Unusual located EP		
1) Interstitial pregnancy	High morbidity and mortality Delayed clinical presentation Possibility of a life-threatening massive hemorrhage	IUP at a high portion of the uterine fundus Not completely surrounded by a 5 mm thickness of myometrium in all planes Heterogeneous but predominantly high T2 SI on MR
2) Cervical pregnancy	Rare (fewer than 1% of EPs) Associated with in vitro fertilization and a previous curettage	"Hourglass" or "figure-of-eight"-shaped uterus Living embryo or GS with peritrophoblastic flow below the internal cervical os Lobulated mass with heterogeneous SI and a partial or complete dark rim on T2WI of MR Irregular peripheral rim enhancement and densely enhancing papillary components on CE image of MR
3) Scar pregnancy	Rare (less than 1% of all pregnancies) Increasing incidence as the rates of cesarean section deliveries rise	GS located in the anterior wall of the inferior part of the uterus (prior cesarean section site) Thinned myometrium anteriorly due to compression by the GS
4) Ovarian pregnancy	3% of all EPs Significant association with the use of intrauterine devices	An ovarian cyst with thick echogenic peripheral vascular ring Often containing acute hematoma with low SI on T2WI Thickened, irregular wall with heterogeneous enhancement on CE image of MR
5) Abdominal pregnancy	1.3% of all EPs Most common location: anterior and posterior uterine pouches, as well as the uterine and adnexal serosa High morbidity and mortality due to delayed detection	Presence of a GS outside the reproductive tract Absence of myometrium surrounding the sac (best observed on T2WI of MR) An enhancement of the peritoneum around the sac on CE image of MR

CE = contrast enhancement, EP = ectopic pregnancy, GS = gestational sac, IUP = intrauterine pregnancy, SI = signal intensity, WI = weighted imaging, β-hCG = β-human chorionic gonadotropin

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REFERENCES

1. Lin EP, Bhatt S, Dogra VS. Diagnostic clues to ectopic pregnancy. *Radiographics* 2008;28:1661-1671
2. Refaat B, Dalton E, Ledger WL. Ectopic pregnancy secondary to in vitro fertilisation-embryo transfer: pathogenic mechanisms and management strategies. *Reprod Biol Endocrinol* 2015;13:30
3. Levine D. Ectopic pregnancy. *Radiology* 2007;245:385-397
4. Lipscomb GH, Stovall TG, Ling FW. Nonsurgical treatment of ectopic pregnancy. *N Engl J Med* 2000;343:1325-1329
5. Eyvazzadeh AD, Levine D. Imaging of pelvic pain in the first trimester of pregnancy. *Radiol Clin North Am* 2006;44:863-877
6. Scibetta EW, Han CS. Ultrasound in early pregnancy: viability, unknown locations, and ectopic pregnancies. *Obstet Gynecol Clin North Am* 2019;46:783-795
7. Parker RA 3rd, Yano M, Tai AW, Friedman M, Narra VR, Menias CO. MR imaging findings of ectopic pregnancy: a pictorial review. *Radiographics* 2012;32:1445-1460; discussion 1460-1462
8. Expert Panel on Women's Imaging; Brown DL, Packard A, Maturen KE, Deshmukh SP, Dudiak KM, Henrichsen TL, et al. ACR appropriateness criteria® first trimester vaginal bleeding. *J Am Coll Radiol* 2018;15(5S):S69-S77
9. Ray JG, Vermeulen MJ, Bharatha A, Montanera WJ, Park AL. Association between MRI exposure during pregnancy and fetal and childhood outcomes. *JAMA* 2016;316:952-961
10. Si MJ, Gui S, Fan Q, Han HX, Zhao QQ, Li ZX, et al. Role of MRI in the early diagnosis of tubal ectopic pregnancy. *Eur Radiol* 2016;26:1971-1980
11. Kao LY, Scheinfeld MH, Chernyak V, Rozenblit AM, Oh S, Dym RJ. Beyond ultrasound: CT and MRI of ectopic pregnancy. *AJR Am J Roentgenol* 2014;202:904-911
12. Gopireddy DR, Le R, Virarkar MK, Freels PD, Hubickey J, Kee-Sampson J, et al. Magnetic resonance imaging evaluation of ectopic pregnancy: a value-added review. *J Comput Assist Tomogr* 2021;45:374-382
13. Durur-Karakaya A, Seker M, Durur-Subasi İ. Diffusion-weighted imaging in ectopic pregnancy: ring of restriction sign. *Br J Radiol* 2018;91:20170528
14. Murugan VA, Murphy BO, Dupuis C, Goldstein A, Kim YH. Role of ultrasound in the evaluation of first-trimester pregnancies in the acute setting. *Ultrasonography* 2020;39:178-189
15. Elsayed S, Farah N, Anglim M. Heterotopic pregnancy: case series and review of diagnosis and management. *Case Rep Obstet Gynecol* 2023;2023:2124191
16. Tamai K, Koyama T, Togashi K. MR features of ectopic pregnancy. *Eur Radiol* 2007;17:3236-3246
17. Omih E, Makris A, Choy C, Bhuskute N. Chronic ectopic pregnancy mimicking pelvic malignancy. *BMJ Case Rep* 2021;14:e233534
18. Kucera C, Cox-Bauer C, Miller C. Apparent ectopic pregnancy with unexpected finding of a germ cell tumor: a case report. *Gynecol Oncol Rep* 2017;21:31-33
19. Seo MR, Choi JS, Bae J, Lee WM, Eom JM, Lee E, et al. Preoperative diagnostic clues to ovarian pregnancy: retrospective chart review of women with ovarian and tubal pregnancy. *Obstet Gynecol Sci* 2017;60:462-468
20. Kim JW, Kim KA, Sim KC, Lee J, Park BN, Song MJ, et al. Ectopic lesions in the abdomen and pelvis: a multimodality pictorial review. *Abdom Radiol (NY)* 2022;47:2254-2276

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자궁 외 임신에 대한 자기공명영상 소견

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자궁 외 임신의 진단은 임상검사 및 초음파 소견을 바탕으로 이루어진다. 자궁 외 임신이 의심되는 상황에서 가장 먼저 시행하게 되는 검사는 혈중 사람 융모성 성선 자극 호르몬의 정량적 평가와 경질 초음파이다. 자궁 외 임신의 평가에 우선적으로 자기공명영상을 시행하지는 않지만, 경질 초음파의 소견이 불확실한 경우, 연조직 대비 해상도가 뛰어나고 스캔 범위가 넓다는 장점을 지니는 자기공명영상을 이용해 볼 수 있다. 자기공명영상을 통해 정확한 착상 위치를 파악한다면 진단과 더불어 복강경을 비롯한 자궁 외 임신의 치료 전략을 세우는 데 도움이 될 수 있을 것이다. 특히, 최근 보조생식술의 시행이 증가하면서 이소성 임신의 빈도가 함께 증가함에 따라, 자기공명영상의 적용 범위는 더욱 넓어질 것으로 기대한다. 본 임상화보에서는 자궁 외 임신 및 관련 상태의 초음파 및 자기공명영상 소견에 대해 살펴보고자 한다. 임상적인 상황과 더불어 초음파 및 자기공명영상 소견에 익숙해진다면, 자궁 외 임신 및 관련 상태의 더욱 정확한 진단 및 치료가 가능할 것으로 기대한다.

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