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Ionizing Radiation Exposure During the First Trimester in a Patient With Heterotopic Pregnancy: A Case Report

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Nikoleta Koutalia [1], Fani Gkrozou [1], Charikleia Skentou [1], Anastasia Vatopoulou [1], Minas Paschopoulos [1]

1. Obstetrics and Gynaecology, University Hospital of Ioannina, Ioannina, GRC

Corresponding author: Nikoleta Koutalia, nikoletakoutalia@gmail.com

Abstract

Heterotopic pregnancy, characterized by the simultaneous presence of intrauterine and ectopic pregnancies, presents a diagnostic challenge due to its rarity and potentially serious complications. We report the case of a 35-year-old primigravida at nine weeks and four days of gestation who presented with acute, severe abdominal pain. Transvaginal ultrasonography revealed a viable intrauterine pregnancy and extensive free intraperitoneal fluid. Computed tomography (CT) confirmed extensive hemoperitoneum. Subsequent urgent diagnostic laparoscopy identified a ruptured left tubal ectopic pregnancy, and laparoscopic left salpingectomy was performed. Following counseling regarding potential fetal risks associated with first-trimester ionizing radiation exposure, the patient elected to continue the pregnancy. This report reviews current evidence on the potential effects of diagnostic radiation exposure during early pregnancy, emphasizing the role of fetal radiation dose and gestational age in risk assessment. It highlights the importance of timely diagnosis and treatment of heterotopic pregnancy while balancing maternal clinical needs with individualized fetal risk counseling and appropriate obstetric follow-up.

Categories: Obstetrics/Gynecology, Radiology, Emergency Medicine
Keywords: computed tomography (ct scan), fetal radiation exposure, first trimester, heterotopic pregnancy, ionizing radiation

Introduction

Heterotopic pregnancy, defined as the simultaneous occurrence of an intrauterine and an ectopic pregnancy, is a rare but potentially life-threatening condition [1]. In spontaneous conceptions, its incidence is estimated to range from one in 4,000 to one in 30,000 pregnancies, although the risk increases substantially with assisted reproductive technologies, reaching approximately one in 100 pregnancies [1-3].

The diagnosis of heterotopic pregnancy remains challenging because the presence of a viable intrauterine pregnancy may provide false reassurance, reducing the clinical suspicion of a concurrent ectopic pregnancy. Furthermore, the clinical presentation is often non-specific. Approximately 30-40% of patients are asymptomatic, with the diagnosis established incidentally during routine ultrasonography. Symptomatic patients may present with abdominal pain, vaginal bleeding, an adnexal mass, or signs of intraperitoneal hemorrhage [4]. Delayed or missed diagnosis increases the risk of tubal rupture, massive hemoperitoneum, hypovolemic shock, and maternal morbidity or mortality, while also threatening the viability of the intrauterine pregnancy.

Herein, we report the case of a previously undetected spontaneous heterotopic pregnancy complicated by massive hemoperitoneum, requiring emergency surgical intervention. The diagnostic workup included abdominal computed tomography (CT) before the diagnosis was established. This case highlights the diagnostic challenges associated with heterotopic pregnancy and provides an opportunity to discuss the fetal safety considerations of abdominal CT performed during early pregnancy. Although established fetal radiation dose thresholds and published risk estimates provide valuable guidance, they cannot replace individualized dose assessment. Accurate estimation of fetal absorbed dose is essential, as exposure varies according to the anatomical region examined, imaging parameters, and gestational age. Therefore, individualized fetal dosimetry remains crucial for evaluating potential biological effects, supporting evidence-based clinical decisions, and providing appropriate counselling while avoiding unnecessary anxiety or inappropriate pregnancy termination.

Case Presentation

A 35-year-old previously healthy female (gravida 1, para 0) with a spontaneous conception at nine weeks and four days of gestation, as dated by her last menstrual period, was referred to our tertiary university hospital from a regional hospital due to severe abdominal pain. The patient reported acute-onset abdominal pain without vaginal bleeding. At the referring hospital, she developed vasovagal episodes associated with diffuse abdominal pain and anemia, requiring transfusion support with two units of packed red blood cells and one unit of fresh frozen plasma prior to transfer.

Upon presentation, she was hemodynamically unstable, with a blood pressure of 80/60 mmHg, heart rate of 130 beats/minute, and body temperature of 37.1°C. Upon arrival at the emergency department, she received an additional one unit of packed red blood cells (total three units) and one unit of fresh frozen plasma. Physical examination revealed diffuse abdominal tenderness with signs of an acute abdomen on palpation. Post-transfusion laboratory findings are summarized in Table *1*.

Laboratory parameter	Patient's Value	Reference Range
White Blood Cell Count	20.3 ×10³ /µL	3.8 - 11.8 ×10³ /µL
Hemoglobin	9.4 g/dL	12 -16 g/dL (adult females)
Hematocrit	27.4 %	34 - 47 %
Platelet Count	186 ×10³ /µL	150 - 450 ×10³ /µL
C-Reactive Protein	7 mg/L	0 - 6 mg/L

TABLE 1: Post-transfusion laboratory findings

Transvaginal ultrasonography (TVUS) demonstrated a viable intrauterine pregnancy with positive embryonic cardiac activity. The crown-rump length (CRL) measured 33.3 mm, corresponding to approximately 10 weeks' gestation (Figure *1*), with a fetal heart rate (FHR) of 162 beats/minute (Figure *2*). The gestational sac appeared appropriately positioned within the uterine cavity. Assessment of the adnexa on transvaginal ultrasonography was limited due to the presence of extensive free intraperitoneal fluid. A large amount of free fluid was present within the pelvis and extending into the abdomen, with the overall sonographic appearance raising suspicion for hemoperitoneum.

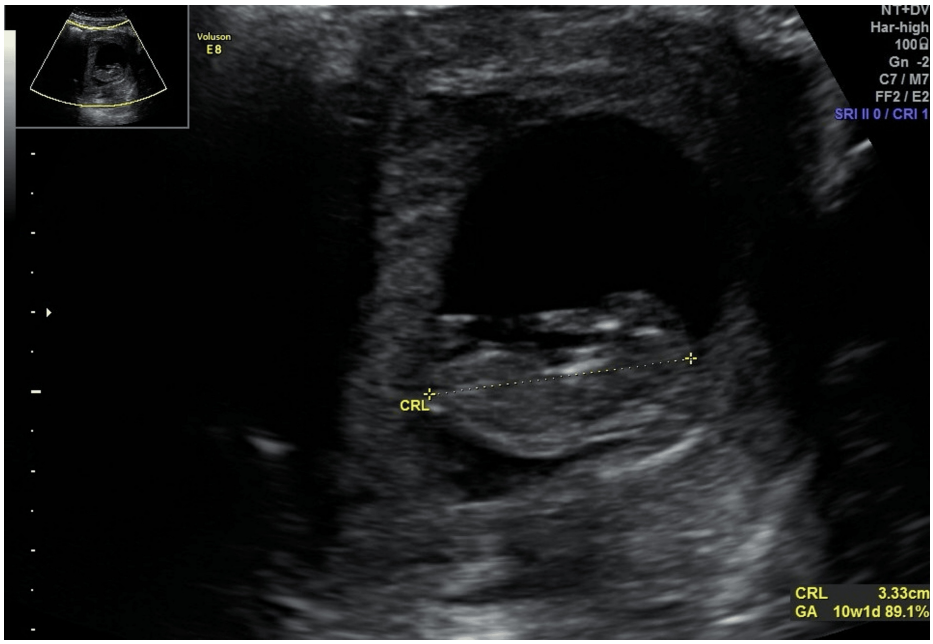


FIGURE 1: Transvaginal ultrasonography demonstrating a viable intrauterine pregnancy.

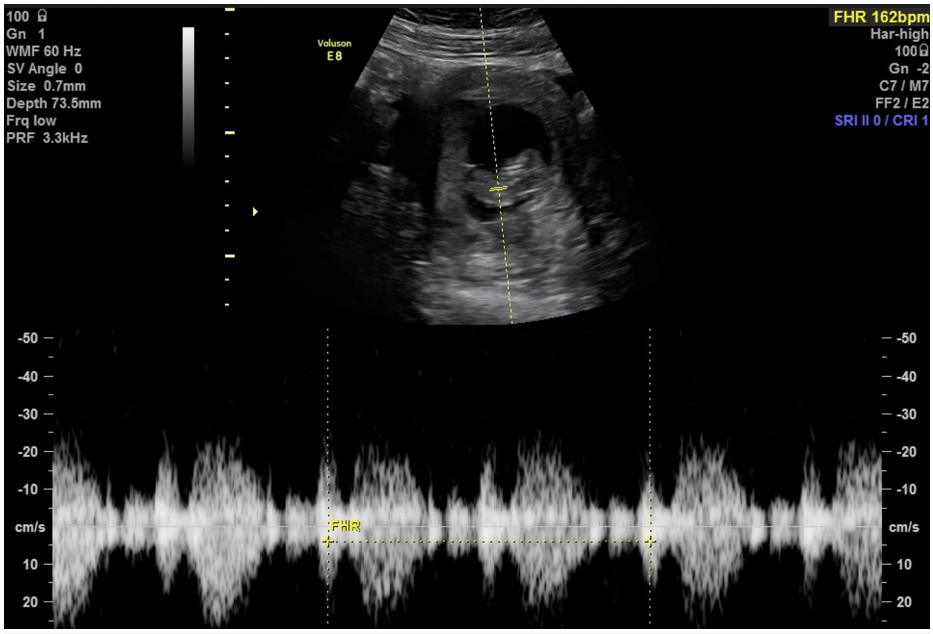


FIGURE 2: Transvaginal ultrasonography demonstrating embryonic cardiac activity.

Following assessment, the general surgery team considered CT imaging necessary for further evaluation. Accordingly, a low-dose CT scan of the abdomen and pelvis was performed without intravenous iodinated contrast administration. The scan demonstrated a significant amount of free intraperitoneal fluid throughout the abdomen, consistent with hemoperitoneum (Figure *3*), along with imaging findings in the left adnexa suggestive of rupture of a left corpus luteum cyst.

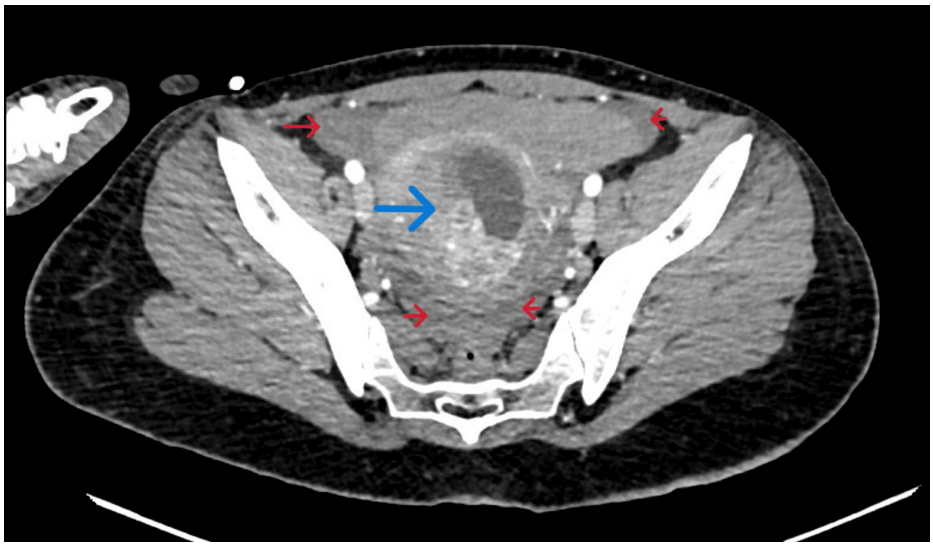


FIGURE 3: CT image demonstrating the intrauterine pregnancy (blue arrow) and hemoperitoneum (red arrows).

An urgent diagnostic laparoscopy was subsequently performed under general anesthesia. Intraoperatively, ectopic gestational tissue was identified within the left fallopian tube, consistent with a ruptured heterotopic pregnancy (Figure *4*), and a laparoscopic left salpingectomy was performed successfully. Approximately 3 L of blood was evacuated from the peritoneal cavity, and abdominal drainage was placed.

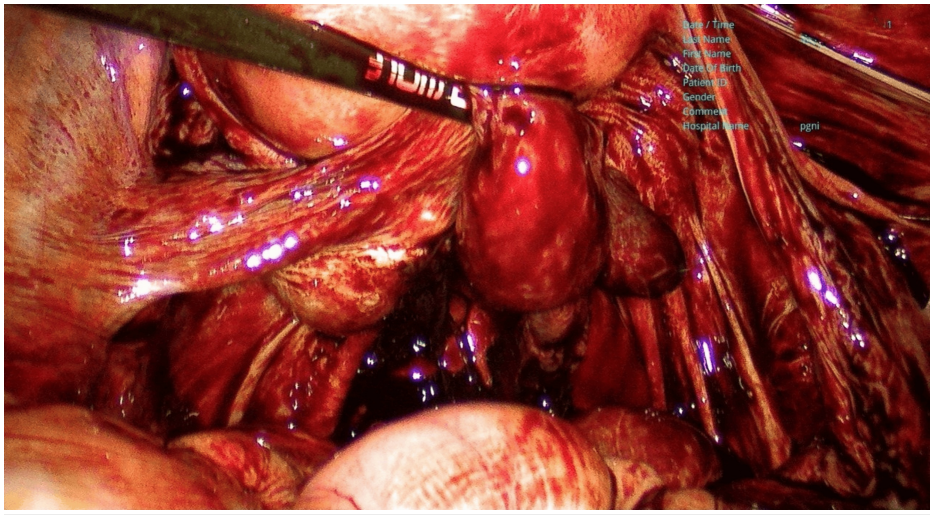


FIGURE 4: Intraoperative laparoscopic image showing a ruptured left tubal ectopic pregnancy with hemoperitoneum.

The postoperative course was uncomplicated, and the abdominal drain was removed on the first postoperative day. Histopathological examination of the resected specimen confirmed a left tubal ectopic pregnancy. Subsequent ultrasonographic evaluation demonstrated a viable intrauterine pregnancy with positive embryonic cardiac activity. Intravenous iron therapy was administered for the management of postoperative anemia, and the patient was discharged in stable clinical condition on the second postoperative day. Following counseling regarding the potential fetal risks associated with abdominal CT imaging performed early in pregnancy, the patient decided to continue the pregnancy. The antenatal anomaly scan revealed no fetal abnormalities. The pregnancy progressed uneventfully to 40 weeks of gestation, when delivery was achieved by cesarean section due to cephalopelvic disproportion. The neonate developed postnatal jaundice, which required clinical evaluation but did not necessitate phototherapy. The subsequent neonatal course was uneventful.

Discussion

Heterotopic pregnancy is characterized by the simultaneous presence of intrauterine and ectopic gestations. Several established risk factors have been identified, including pelvic inflammatory disease, previous ectopic pregnancy, prior tubal surgery, intrauterine device use, advanced maternal age (>35 years), smoking, vaginal douching, and infertility, particularly when treated with assisted reproductive technology (ART) [5]. Among these, ART represents the strongest risk factor, with women undergoing in vitro fertilization (IVF) having a substantially increased risk of heterotopic and other abnormal implantation pregnancies compared with the general population [6].

The diagnosis of heterotopic pregnancy is established by sonographic demonstration of both an intrauterine pregnancy and a concurrent ectopic gestation. However, diagnosis may be challenging when an adnexal lesion cannot be readily distinguished from a hemorrhagic corpus luteum, particularly in the absence of a visible yolk sac or embryo. Management should be individualized according to location of ectopic pregnancy, gestational age, presence of intra-abdominal bleeding, and patient's reproductive goals [7]. Surgical intervention is required in approximately 78-91% of patients with heterotopic pregnancy, with laparoscopic salpingectomy representing the treatment of choice for tubal heterotopic pregnancy. During surgery, meticulous care should be taken to minimize uterine manipulation and preserve the intrauterine pregnancy [4]. The impact of surgical management on the risk of early intrauterine pregnancy loss remains controversial. Overall, patients with heterotopic pregnancy have been reported to be at increased risk of spontaneous or medically indicated pregnancy loss and are approximately 30% less likely to achieve a live birth than women with isolated intrauterine pregnancies [8]. Nevertheless, more recent studies have demonstrated favorable outcomes following surgery. Chen et al., in a retrospective analysis, reported an early pregnancy loss rate of 14.4%, a live birth rate of 85.6%, and a preterm birth rate of 24.2% following surgical management of heterotopic pregnancy [9]. On the other hand, other studies have found no evidence that surgical treatment itself increases the risk of early intrauterine pregnancy loss [10].

Radiation exposure during pregnancy raises concerns regarding potential fetal effects, particularly when the fetus is directly included within the imaging field. Diagnostic examinations that do not involve direct irradiation of the uterus generally result in negligible fetal exposure and are considered to pose minimal risk. The biological effects of ionizing radiation are primarily mediated through cellular damage, including cell death and DNA injury. Cell death may lead to deterministic effects, such as fetal growth restriction, congenital malformations, neurodevelopmental impairment, and pregnancy loss, whereas DNA damage

underlies stochastic effects, including carcinogenesis and genetic mutations. Deterministic effects are dose-dependent and occur only after a threshold radiation dose has been exceeded, while stochastic effects have no established threshold, with their probability increasing as radiation dose increases. Radiation exposure from diagnostic imaging is commonly quantified using several dosimetric parameters, including absorbed dose (Gray (Gy)), effective dose (sievert (Sv)), CT dose index (CTDI, mGy), and dose-length product (DLP, mGy·cm). Absorbed dose represents the amount of ionizing radiation energy deposited per 1 kg of tissue, whereas effective dose accounts for the varying radiosensitivity of different organs and tissues, providing the best estimate of the overall biological risk associated with radiation exposure. Because direct measurement of fetal radiation dose is not feasible, fetal exposure is estimated using anthropomorphic phantom measurements and computational dosimetric simulation models [11].

According to the literature, deterministic fetal effects generally occur only at radiation doses exceeding 200 mGy [11]. The fetal central nervous system is most susceptible to the effects of ionizing radiation at 8-15 weeks of gestation, a period during which neuronal proliferation and migration are highly active. Evidence derived primarily from studies of atomic bomb survivors suggests that this is the period of greatest vulnerability to radiation-induced neurodevelopmental impairment. During this period, the threshold for radiation-induced reductions in intelligence quotient (IQ) and intellectual disability has been reported to be approximately 180 mGy; this threshold increases with advancing gestational age [11,12]. According to American College of Obstetricians and Gynecologists (ACOG) Guidelines for Diagnostic Imaging During Pregnancy and Lactation, the estimated threshold for radiation-induced microcephaly is approximately 200 mGy, while the threshold for severe intellectual disability has been reported to range from 60 to 310 mGy, although the lowest clinically documented dose associated with this outcome was approximately 610 mGy [13]. Current evidence suggests that fetal structural anomalies, growth restriction, and pregnancy loss have not been reported following radiation exposures of less than 50 mGy, a dose that exceeds fetal exposure associated with virtually all diagnostic imaging procedures. Between 16 and 25 weeks of gestation, the fetal brain remains susceptible to radiation; however, the threshold for severe intellectual disability increases to approximately 250-280 mGy, with substantially lower sensitivity beyond this period. Published evidence indicates that, beyond 25 weeks of gestation, the risk of radiation-induced fetal effects is markedly reduced, and clinically indicated imaging may be performed following appropriate multidisciplinary consultation and radiation dose optimization [14].

In contrast, the potential increase in childhood cancer following in utero radiation exposure is considered a stochastic effect, with no established threshold, although the absolute risk associated with diagnostic imaging remains extremely low. A fetal radiation dose of 10-20 mGy has been estimated to increase the risk of childhood leukemia by approximately 1.5- to 2-fold above the baseline incidence of approximately one in 3,000 births [13,15]. Evidence from the published literature suggests that the increased lifetime risk of childhood malignancy is approximately 0.06 per 100 rad of fetal irradiation, although lower estimates of 0.022 and 0.028 per 100 rad have been reported by the British Oxford Survey of Childhood Cancer and the Life Span Study of Japanese atomic bomb survivors, respectively [16]. Notably, the average annual background radiation exposure is approximately 2.4 mSv, whereas fetal exposure from CT examinations performed outside the abdomen or pelvis is typically less than 5 mSv. Abdominal and pelvic CT examinations are associated with higher fetal radiation exposure, generally exceeding 10 mSv [11]. Although published fetal dose estimates vary considerably, recent studies have reported fetal doses of approximately 25-30 mSv for a standard CT examination of the abdomen and pelvis. Despite these higher exposures, the estimated fetal doses remain well below the thresholds associated with deterministic fetal effects. With respect to stochastic effects, a standard abdominal and pelvic CT examination, with an estimated fetal dose of approximately 30 mSv, may approximately double the relative risk of childhood cancer. Nevertheless, given the low baseline incidence of childhood malignancy (approximately 1.0-2.5 cases per 1,000 children), this increase translates into only a modest absolute risk [17].

Exposure to diagnostic levels of ionizing radiation alone is not considered an indication for pregnancy termination. When multiple radiologic examinations are performed during pregnancy, consultation with a medical radiation physicist is recommended to estimate the cumulative fetal radiation dose. CT should not be withheld when clinically justified, provided that the potential benefits outweigh the risks and appropriate counseling is offered. Whenever diagnostically appropriate and readily available, MRI should be considered because it does not involve ionizing radiation. Adherence to the As Low As Reasonably Achievable (ALARA) principle [18] is essential during imaging in pregnancy and includes restricting the scanned anatomical region, minimizing the number of acquisition phases, and employing low-dose CT protocols whenever clinically feasible. Studies have demonstrated that ultra-low-dose CT protocols can achieve substantial reductions in radiation exposure while maintaining adequate diagnostic image quality for selected indications, such as suspected appendicitis, urinary tract calculi, or intra-abdominal infection [19]. Furthermore, thermoluminescent dosimeters have been proposed [20]. Although iodinated contrast agents readily cross the placenta, available animal and human data have not demonstrated teratogenic, mutagenic, or clinically significant adverse effects on fetal thyroid function. They were classified as a Class B drug in pregnant women by the United States Food and Drug Administration (FDA). Nevertheless, their use during pregnancy should be restricted to situations in which contrast enhancement is expected to provide essential diagnostic information that will directly influence maternal or fetal management [13,21].

In accordance with recommendations from the American College of Radiology (ACR), informed consent

should be obtained whenever ionizing radiation imaging is performed in a pregnant patient, ensuring that the potential benefits and risks are appropriately discussed [12].

Conclusions

Heterotopic pregnancy should be considered in pregnant patients presenting with acute abdominal pain and hemoperitoneum, even when a viable intrauterine pregnancy has been confirmed. This case underscores the importance of prompt diagnosis and timely surgical intervention to prevent potentially life-threatening maternal complications. Fetal radiation exposure should be individually assessed whenever possible, taking into account the imaging modality, estimated fetal dose, and gestational age at exposure. Furthermore, the potential stochastic risk of childhood malignancy, although small, should be acknowledged. Therefore, decisions regarding diagnostic imaging during pregnancy should be guided by clinical necessity, individualized risk assessment, and appropriate counseling. Despite the absence of apparent complications during the immediate postnatal period, continued pediatric follow-up is advisable to monitor the child's growth and development and to identify any potential late effects. This highlights the importance of long-term follow-up and multidisciplinary care in pregnancies involving significant diagnostic radiation exposure.

Additional Information

Author Contributions

All authors have reviewed the final version to be published and agreed to be accountable for all aspects of the work.

Acquisition, analysis, or interpretation of data: Nikoleta Koutalia, Anastasia Vatopoulou

Drafting of the manuscript: Nikoleta Koutalia, Fani Gkrozou

Concept and design: Fani Gkrozou, Charikleia Skentou, Minas Paschopoulos

Critical review of the manuscript for important intellectual content: Fani Gkrozou, Charikleia Skentou, Anastasia Vatopoulou, Minas Paschopoulos

Supervision: Fani Gkrozou

Disclosures

Human subjects: Informed consent for treatment and open access publication was obtained or waived by all participants in this study. **Conflicts of interest:** In compliance with the ICMJE uniform disclosure form, all authors declare the following: **Payment/services info:** All authors have declared that no financial support was received from any organization for the submitted work. **Financial relationships:** All authors have declared that they have no financial relationships at present or within the previous three years with any organizations that might have an interest in the submitted work. **Other relationships:** All authors have declared that there are no other relationships or activities that could appear to have influenced the submitted work.

References

1. ACOG practice bulletin no. 193: tubal ectopic pregnancy. Obstet Gynecol. 2018, 131:e91-e103. 10.1097/AOG.0000000000002560
2. Maleki A, Khalid N, Rajesh Patel C, El-Mahdi E: The rising incidence of heterotopic pregnancy: current perspectives and associations with in-vitro fertilization. Eur J Obstet Gynecol Reprod Biol. 2021, 266:138-44. 10.1016/j.ejogrb.2021.09.031
3. Hassani KI, Bouazzaoui AE, Khatouf M, Mazaz K: Heterotopic pregnancy: a diagnosis we should suspect more often. J Emerg Trauma Shock. 2010, 3:304. 10.4103/0974-2700.66563
4. Zhao Y, Bai Y, Feng C, Ke R, Lu Y: Spontaneous heterotopic pregnancy and its clinical implications . Int J Womens Health. 2026, 18:601063. 10.2147/IJWH.S601063
5. Clayton HB, Schieve LA, Peterson HB, Jamieson DJ, Reynolds MA, Wright VC: A comparison of heterotopic and intrauterine-only pregnancy outcomes after assisted reproductive technologies in the United States from 1999 to 2002. Fertil Steril. 2007, 87:303-9. 10.1016/j.fertnstert.2006.06.037
6. Wang ET, Kathiresan AS, Bresee C, Greene N, Alexander C, Pisarska MD: Abnormal implantation after fresh and frozen in vitro fertilization cycles. Fertil Steril. 2017, 107:1153-8. 10.1016/j.fertnstert.2017.03.012
7. Nguyen KP, Hudspeth M, Milestone H: Spontaneous heterotopic pregnancy: diagnosis and management . Case Rep Obstet Gynecol. 2022, 2022:2994808. 10.1155/2022/2994808
8. Cucinella G, Gullo G, Etrusco A, Dolce E, Culmone S, Buzzaccarini G: Early diagnosis and surgical management of heterotopic pregnancy allows us to save the intrauterine pregnancy. Prz Menopauzalny. 2021, 20:222-5. 10.5114/pm.2021.111277
9. Chen L, Wen H, Xu D, Chen LQ, He J: Management and pregnancy outcomes of heterotopic pregnancy (Article in Chinese). Zhonghua Fu Chan Ke Za Zhi. 2018, 53:768-75. 10.3760/cma.j.issn.0529-567x.2018.11.007

10. Jeon JH, Hwang YI, Shin IH, Park CW, Yang KM, Kim HO: The risk factors and pregnancy outcomes of 48 cases of heterotopic pregnancy from a single center. J Korean Med Sci. 2016, 31:1094-9. 10.3346/jkms.2016.31.7.1094
11. Shetty MK: Abdominal computed tomography during pregnancy: a review of indications and fetal radiation exposure issues. Semin Ultrasound CT MR. 2010, 31:3-7. 10.1053/j.sult.2009.09.001
12. ACR Practice guideline for imaging pregnant or potentially pregnant adolescents and women with ionizing radiation. ACR Practice Guideline for Continuing Medical Education. American College of Radiology, Reston, VA; 2008. 23-37.
13. American College of Obstetricians and Gynecologists: Guidelines for diagnostic imaging during pregnancy and lactation. (2026). Accessed: November 10, 2026: https://www.acog.org/clinical/clinical-guidance/committee-opinion/articles/2017/10/guidelines-for-diagnostic-imaging-....
14. Committee opinion no. 656: guidelines for diagnostic imaging during pregnancy and lactation . Obstet Gynecol. 2016, 127:e75-80. 10.1097/AOG.0000000000001316
15. Gjelsteen AC, Ching BH, Meyermann MW, Prager DA, Murphy TF, Berkey BD, Mitchell LA: CT, MRI, PET, PET/CT, and ultrasound in the evaluation of obstetric and gynecologic patients. Surg Clin North Am. 2008, 88:361-90, vii. 10.1016/j.suc.2008.01.005
16. Bentur Y: Ionizing and nonionizing radiation in pregnancy . Medication Safety in Pregnancy and Breastfeeding. Koren G (ed): McGraw Hill, Philadelphia (PA); 2007. 221-48.
17. Shin DS, Poder L, Courtier J, Naeger DM, Westphalen AC, Coakley FV: CT and MRI of early intrauterine pregnancy. AJR Am J Roentgenol. 2011, 196:325-30. 10.2214/AJR.09.3723
18. CDC: ALARA - As Low As Reasonably Achievable recommendations . (2026). Accessed: November 14, 2026: https://www.cdc.gov/radiation-health/safety/alara.html.
19. Udayasankar UK, Li J, Baumgarten DA, Small WC, Kalra MK: Acute abdominal pain: value of non-contrast enhanced ultra-low-dose multi-detector row CT as a substitute for abdominal radiographs. Emerg Radiol. 2009, 16:61-70. 10.1007/s10140-008-0743-0
20. Albakri AA, Alzahrani MM, Alghamdi SH: Medical imaging in pregnancy: safety, appropriate utilization, and alternative modalities for imaging pregnant patients. Cureus. 2024, 16:e54346. 10.7759/cureus.54346
21. Webb JA, Thomsen HS, Morcos SK: The use of iodinated and gadolinium contrast media during pregnancy and lactation. Eur Radiol. 2005, 15:1234-40. 10.1007/s00330-004-2583-y