EUROPEAN SOCIETY OF RADIOLOGY

eBook for Undergraduate Education in Radiology

CHAPTER: Imaging of the Female Pelvis

Preface

Undergraduate teaching of radiology in Europe is provided according to national schemes and may vary considerably from one academic institution to another. Sometimes, the field of radiology is considered as a "cross-cutting discipline" or taught within the context of other clinical disciplines, e.g., internal medicine or surgery.

This e-book has been created in order to serve medical students and academic teachers throughout Europe to understand and teach radiology as a whole coherent discipline, respectively. Its contents are based on the *Undergraduate Level of the ESR European Training Curriculum for Radiology* and summarize the so-called ***core elements*** that may be considered as the basics that every medical student should be familiar with. Although specific radiologic diagnostic skills for image interpretation cannot be acquired by all students and rather belong to the learning objectives of the *Postgraduate Levels of the ESR Training Curricula*, the present e-book also contains some ***further insights*** related to modern imaging in the form of examples of key pathologies, as seen by the different imaging modalities. These are intended to give the interested undergraduate student an understanding of modern radiology, reflecting its multidisciplinary character as an organ-based specialty.

We would like to extend our special thanks to the authors and members of the ESR Education Committee who have contributed to this eBook, to Carlo Catalano, Andrea Laghi and András Palkó who initiated this project, and to the ESR Office, in particular Bettina Leimberger and Danijel Lepir, for all their support in realising this project.

We hope that this e-book may fulfil its purpose as a useful tool for undergraduate academic radiology teaching.

Minerva Becker

Chapter Outline

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eBook for Undergraduate Education in Radiology

Based on the ESR Curriculum for Undergraduate Radiological Education

Chapter: **Imaging of the Female Pelvis**

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Chapter Outline

Anatomy

The female pelvis is a anatomically complex, housing the reproductive and some parts of the urinary system. The changes it undergoes throughout life, especially during pregnancy, make it a focal point of medical imaging.

The female reproductive system consists of:

- Ovaries: Produce and store eggs (ova)
- Fallopian tubes: Transport eggs from the ovaries to the uterus
- Uterus: Site for fetal development during pregnancy
- Cervix: Connects the uterus to the vagina
- Vagina: Birth canal

The pelvic organs are surrounded by the peritoneum. Anterior to the uterus, the peritoneal cavity extends between the uterine isthmus and posterior bladder wall to form the vesicouterine pouch. The rectouterine pouch, called also the cul-de-sac or pouch of Douglas, is the extension of the peritoneal cavity between the rectum and the cervix and posterior uterine wall.

Chapter Outline

Ovaries

Anatomy: The ovaries are bilateral, almond-shaped organs situated laterally in the pelvic cavity and measure approximately 1.5-3.0 cm × 1.5-3.0 cm × 1.0-2.0 cm (length x width x thickness) (corresponding to a volume of 1.2-9.4 cm3). Each ovary is divided into:

- Medulla: The central part containing blood vessels, lymphatic vessels, and nerves.
- Cortex: The outer layer where oogenesis occurs, containing various stages of ovarian follicles.
- Germinal epithelium: The outermost layer.
- Tunica albuginea: A dense connective tissue layer beneath the germinal epithelium.

Function: The ovaries are responsible for oogenesis (production of ova or eggs) and hormone production, including estrogen and progesterone, which play vital roles in the menstrual cycle, pregnancy, and secondary sexual characteristics.

Physiology: The primary structures are the follicles, ranging from primordial to mature Graafian follicles. The ovarian stroma supports these follicles and contains interstitial cells which produce hormones.

Chapter Outline

Ovaries

Blood Supply:

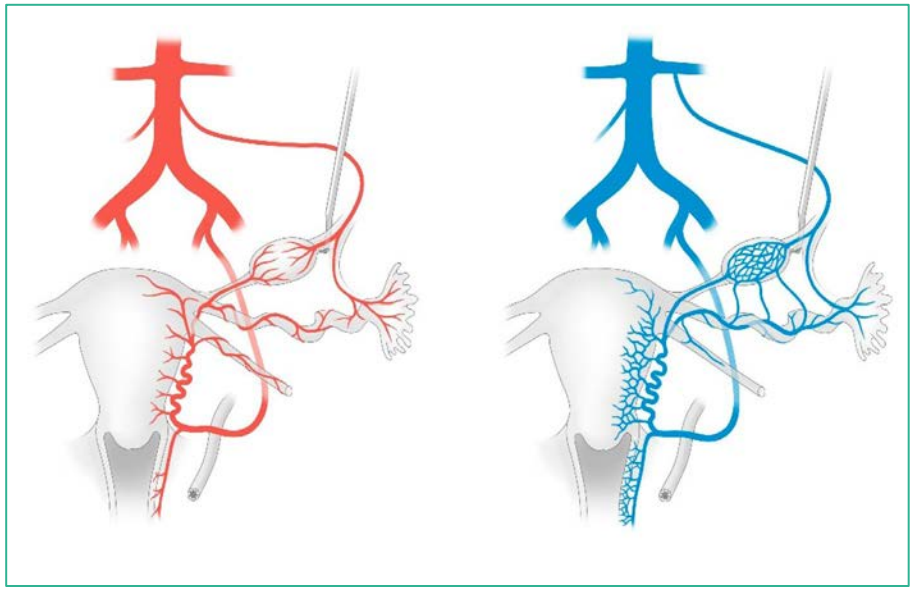
- Ovarian Arteries:
  Directly arise from the abdominal aorta, usually inferior to the renal arteries.
  The ovarian arteries travel within the suspensory ligament of the ovary, called the infundibulopelvic ligament, to reach the ovaries.
- Uterine Arteries:
  Arise from the internal iliac arteries. A part of the blood from the uterine arteries also supplies the ovaries via anastomoses with the branches of the ovarian arteries. This ensures a rich vascular network, facilitating hormonal transportation and follicular development.
- Venous Drainage:
  - Ovarian Veins: These veins are responsible for venous drainage of the ovaries. The right ovarian vein usually drains directly into the inferior vena cava, whereas the left ovarian vein typically drains into the left renal vein.

Lymphatic Drainage:

- Para-aortic Lymph Nodes:
  The majority of the lymphatic drainage from the ovaries flows to the para-aortic or lumbar lymph nodes, which are located alongside the abdominal aorta. This is crucial in the context of ovarian cancers, as these nodes are frequently assessed for metastatic spread.
- Pelvic Lymph Nodes:
  A small portion of lymph from the ovaries may also drain to pelvic lymph nodes. However, this is a less common pathway compared to the para-aortic nodes.

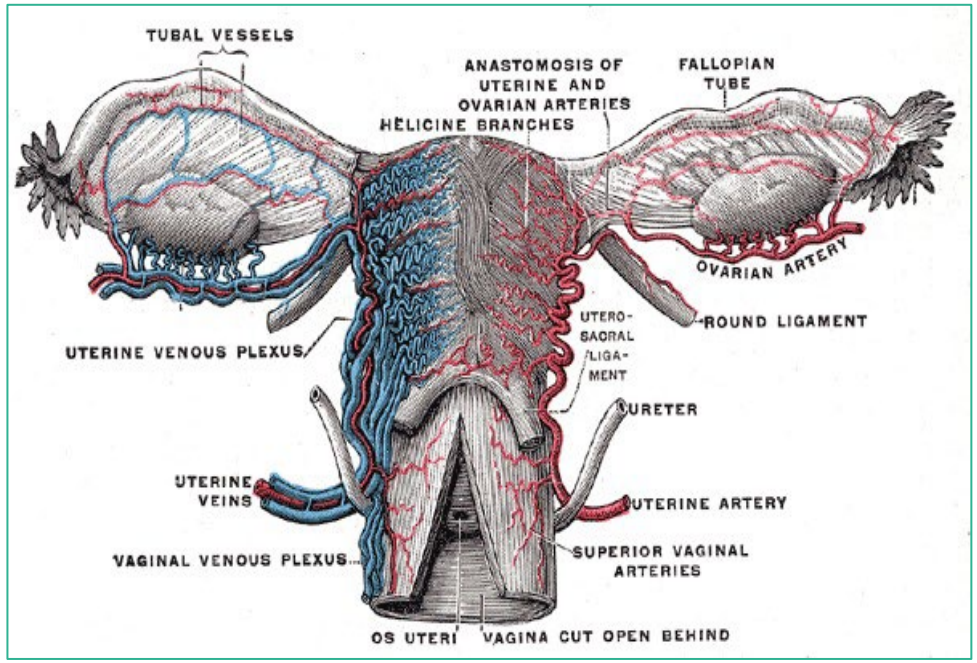
Chapter Outline

Ovaries



Female reproductive system blood supply

Reproduced from: Freytag D. et al. Challenges Posed by Embryonic and Anatomical Factors in Systematic Lymphadenectomy for Endometrial Cancer. J. Clin. Med. 2020, 9, 4107. https://doi.org/10.3390/jcm9124107



Female reproductive system anatomy and blood supply: Tubal vessels, anastomosis of uterine and ovarian arteries, helicine branches, Fallopian tub, ovarian artery, uterine venous plexus, uterosacral ligament, ureter, uterine artery and veins, superior vaginal arteries, vaginal venous plexus, os uteri.

Reproduced from: Henry Gray (1918) Anatomy of the Human Body, Bartleby.com: Gray's Anatomy, Illustration 589

Chapter Outline

Ovarian Changes Over Time

Postmenopausal Ovaries:

- Decrease in size with age, often hard to detect on ultrasound.
- Visualized in about 96% of premenopausal cases, but only 63.5% of postmenopausal cases.

Premenarchal Ovaries:

- Best viewed transabdominally or transrectally before puberty.
- Display as small structures, with early signs of folliculogenesis evident as puberty nears.
- During adolescence, there's a diverse growth of follicles; sometimes mistaken for polycystic ovaries.

Reproductive Age Ovaries:

- Morphological changes occur due to hormone fluctuations.
- Newborns have around two million follicles; only a fraction mature and ovulate during a woman's life.
- From the fifth to the seventh day of the menstrual cycle, secondary antral follicles are visible. One dominant follicle typically emerges during the cycle

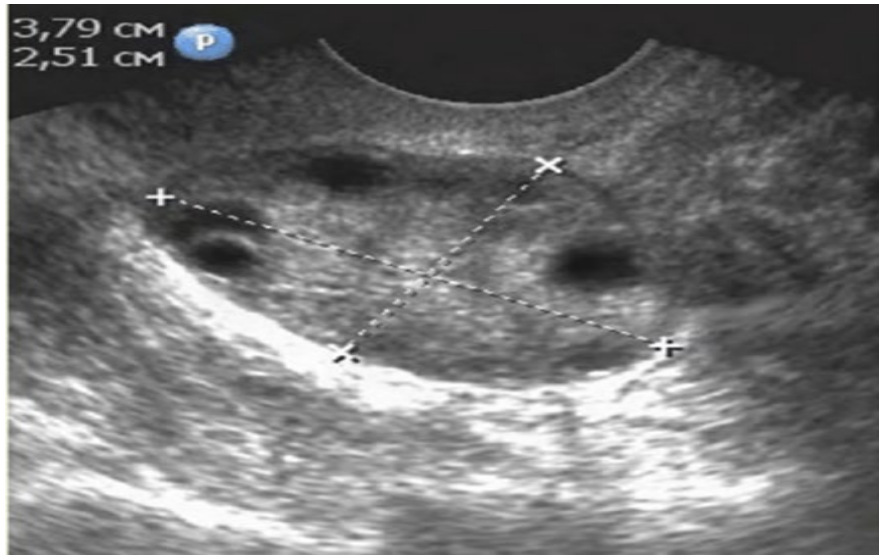
Anatomical Variants:

- Accessory Ovary: A rare occurrence of an additional smaller ovary.
- Ectopic Ovary: An ovary located outside its typical position.

Chapter Outline

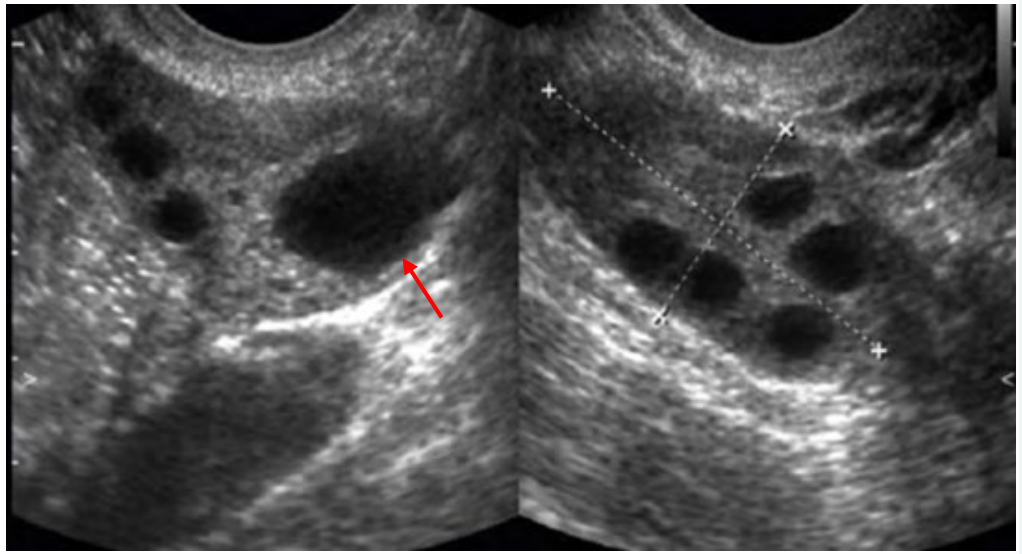
Ovarian Radiological Features

Radiological Features: On ultrasound, the ovaries appear as elliptical structures with an echogenic stroma. During the early menstrual cycle, multiple anechoic follicles can be seen.



Normal ovary of a healthy woman, aged 21 years in the early proliferative phase. Several follicles of 4-6 mm are located along its perimeter

Reproduced from: Abdullaiev R Ya et al. (05 2018). EC GYNAECOLOGY Research Article Transvaginal Echography in Assessing of Structures and Functional Changes in Polycystic Ovaries



Normal ovaries. In the middle proliferative phase, the ripening follicle is visualized in the right ovary (red Arrow)

Reproduced from: Abdullaiev R Ya et al. (05 2018). EC GYNAECOLOGY Research Article Transvaginal Echography in Assessing of Structures and Functional Changes in Polycystic Ovaries

Chapter Outline

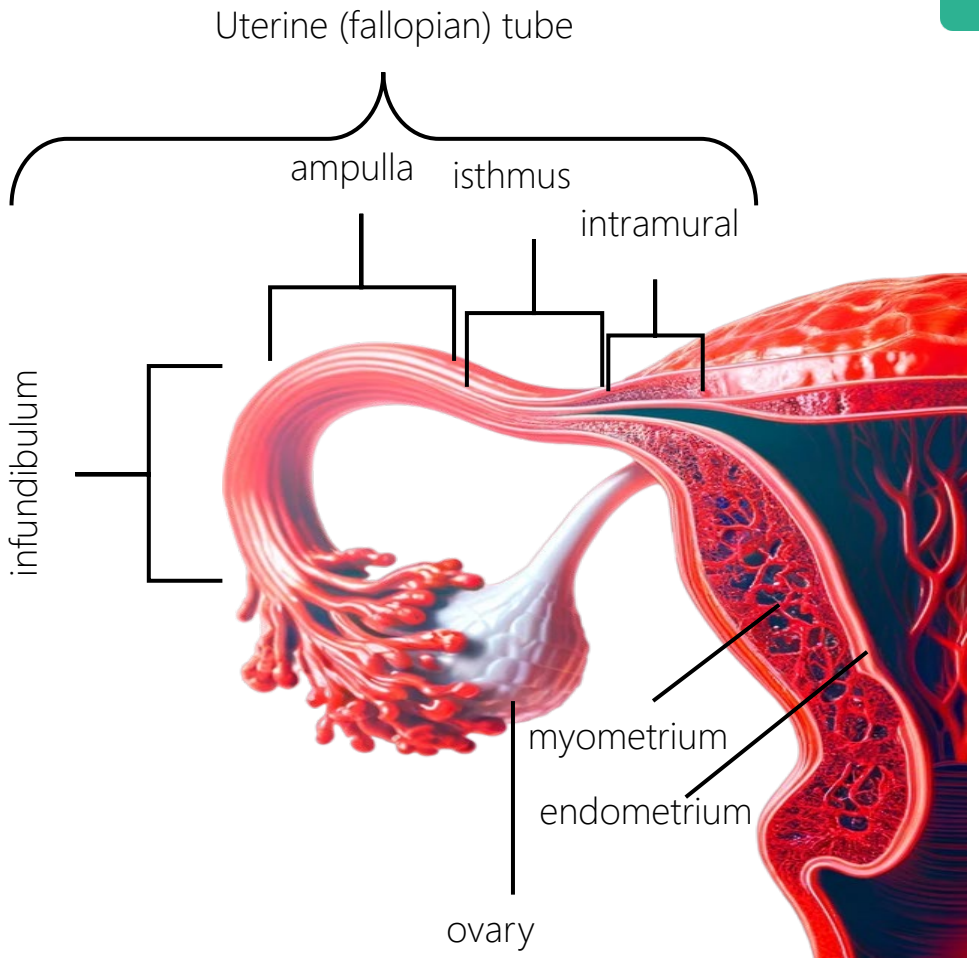
Fallopian Tubes

Anatomy: The fallopian tubes are bilateral tubular structures connecting the ovaries and uterus. They're divided into

- **Infundibulum**: The funnel-shaped segment with fimbriae.
- **Ampulla**: The longest segment.
- **Isthmus**: The thicker-walled segment closer to the uterus.
- **Interstitial part**: Located within the uterine wall.

Function: The fallopian tubes transport mature ova from the ovaries to the uterus. They are also the site where fertilization commonly takes place if spermatozoa are present.

Blood supply to the fallopian tubes is derived from branches of both the ovarian and uterine arteries. The blood drainage from the fallopian tubes is via the corresponding veins, i.e., the ovarian and uterine veins



Anatomy of the Fallopian Tube

Chapter Outline

Fallopian Tubes: Radiological Features

Anatomical Variants:

- Duplicate tubes: Rare duplication of a section or the entirety of the tube.
- Congenital absence: Absence of one or both tubes.

Radiological features: Generally not distinctly visualized under ultrasound unless pathology like hydrosalpinx or ectopic pregnancy is suspected (see later).

Hysterosalpingography (HSG) is an X-ray imaging technique to assess fallopian tube patency and to outline the internal shape of the uterus. In HSG a thin tube is inserted into the vagina and cervix and contrast material is injected into the uterus.

In a normal HSG, the uterine cavity is well-defined, and the contrast fills both fallopian tubes and spills into the peritoneal cavity, indicating tubal patency.

Normal hysterosalpingogram (HSG), with bilateral intraperitoneal spill of contrast. No filling defects. Case courtesy of Mohammad Taghi Niknejad, Radiopaedia.org, rID: 93384

Chapter Outline

Uterus

Anatomy: The uterus is a pear-shaped muscular organ positioned anterior to the rectum and posterior to the bladder. In non-pregnant females, it lies mostly within the pelvic cavity. In non-pregnant women, it typically measures about 7.5 cm in length, 5 cm in breadth at its upper part, and nearly 2.5 cm in thickness. It's divided into:

- Fundus: The top portion.
- Body or Corpus: The central segment.
- Cervix: The lower portion projecting into the vagina.
- The uterine corpus is composed of three layers:
- Endometrium: The inner mucosal layer, which undergoes cyclic changes during the menstrual cycle and is shed during menstruation.
- Myometrium: The thick, muscular middle layer responsible for uterine contractions during menstruation and childbirth.
- Perimetrium (or Serosa): The outermost thin Peritoneal layer covering the uterus.

Physiology: Estrogen causes proliferation of the endometrial lining, while progesterone prepares it for potential implantation. If pregnancy doesn't occur, a drop in these hormone levels leads to menstruation.
Function: The uterus houses and nourishes the developing fetus during pregnancy. During menstrual cycles, its inner lining (endometrium) thickens in preparation for a potential implantation of an embryo.

Blood Supply:

- Uterine Arteries: These arise from the internal iliac arteries and provide the primary blood supply.
- Ovarian Arteries: They also contribute to the blood supply, especially to the lateral part of the uterus.

Lymphatic Drainage:
Lymph from the uterus primarily drains into the internal and external iliac lymph nodes, as well as the sacral and aortic lymph nodes

Chapter Outline

Anatomical Variants and Anomalies

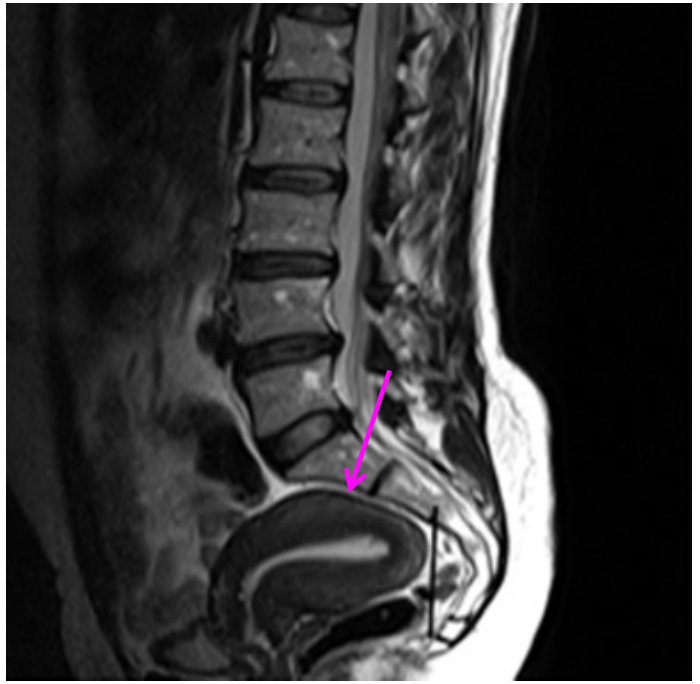
In the study of female pelvic radiology, understanding the diversity in the anatomy of the uterus is crucial. While there are numerous variants and anomalies, this section focuses on the most common ones. For a comprehensive understanding of less common conditions, readers are encouraged to refer to ASRM Müllerian anomalies classification [6].

Most Common Uterine Variants

- Anteverted Uterus
  Description: The most common uterine position, where the uterus tilts forward at the cervix.
  Clinical Implication: Generally, no symptoms.

- Retroverted Uterus
  Description: The uterus tilts backward at the cervix, also known as a "tipped uterus."
  Clinical Implication: Often asymptomatic, may cause discomfort during menstruation or intercourse in some cases.

- Retroflexed Uterus
  Description: A posteriorly oriented uterus with the body flexed backward on the cervix.
  Clinical Implication: Typically, a normal variant, sometimes with symptoms similar to a retroverted uterus.



MRI of the pelvis showing a retroverted uterus

Reproduced from: Zidan MMA et al. Incidental extraspinal findings in the lumbar spine during magnetic resonance imaging of intervertebral discs. *Heliyon*. 2018;4(9):e00803. Published 2018 Sep 19. doi:10.1016/j.heliyon.2018.e00803

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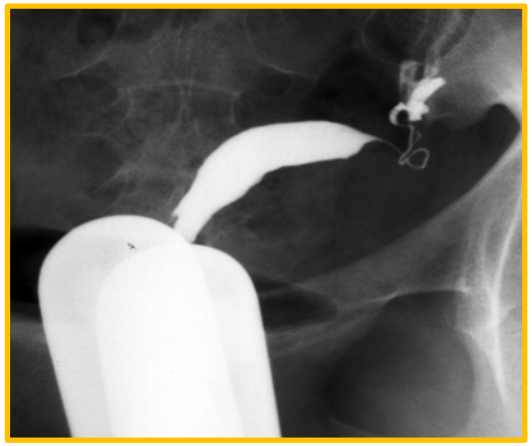
Anatomical Variants and Anomalies

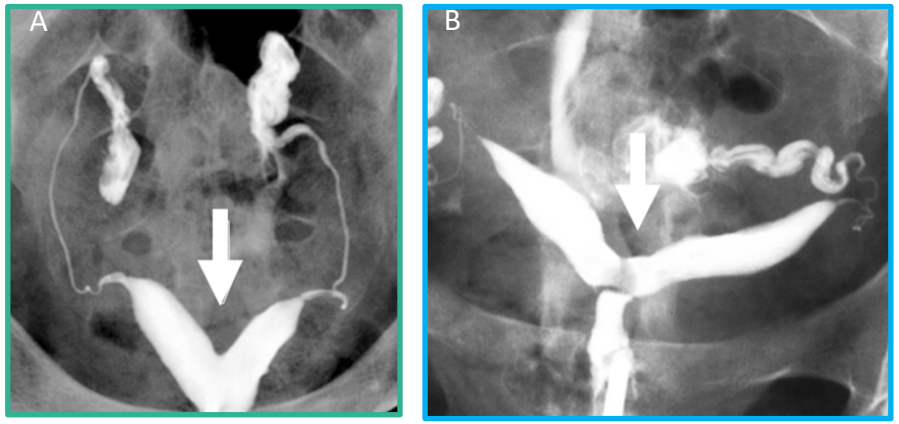
Most Common Müllerian Duct Anomalies

- Unicornuate Uterus:
  => underdevelopment of one Müllerian duct leading to a uterus with a single horn.
- Bicornuate Uterus (Unicollis and Bicollis):
  => uterus with two cavities, either sharing a single cervix (unicollis) or with two separate cervixes (bicollis).
  Clinical Implication: Generally, no symptoms.
  Both types associated with Increased miscarriage risk, preterm labor and malpresentation (e.g., breech presentation). Reduced fertility reported.
- Septate Uterus:
  =>most common anomaly and features a normal external shape but has an internal septum dividing it into two cavities.
  Clinical Implication: Associated with High miscarriage rate and Infertility.
- Subseptate Uterus:
  => similar to septate uterus but with a partial septum.
  Clinical Implication: Associated with miscarriage and preterm delivery.
- Arcuate Uterus:
  => mild form of septate uterus, with slight indentation at the top of the uterine cavity
  Clinical Implication: Generally minimal implications but slight increase in miscarriage rate.



Hysterosalpingography showing a left unicornuate uterus with an ipsilateral patent left tube.

Reproduced from: Sönmezer, M etal-(2006). Laparoscopic management of rudimentary uterine horn pregnancy: case report and literature review. *JSLS : Journal of the Society of Laparoendoscopic Surgeons*, *10*(3), 396–399.

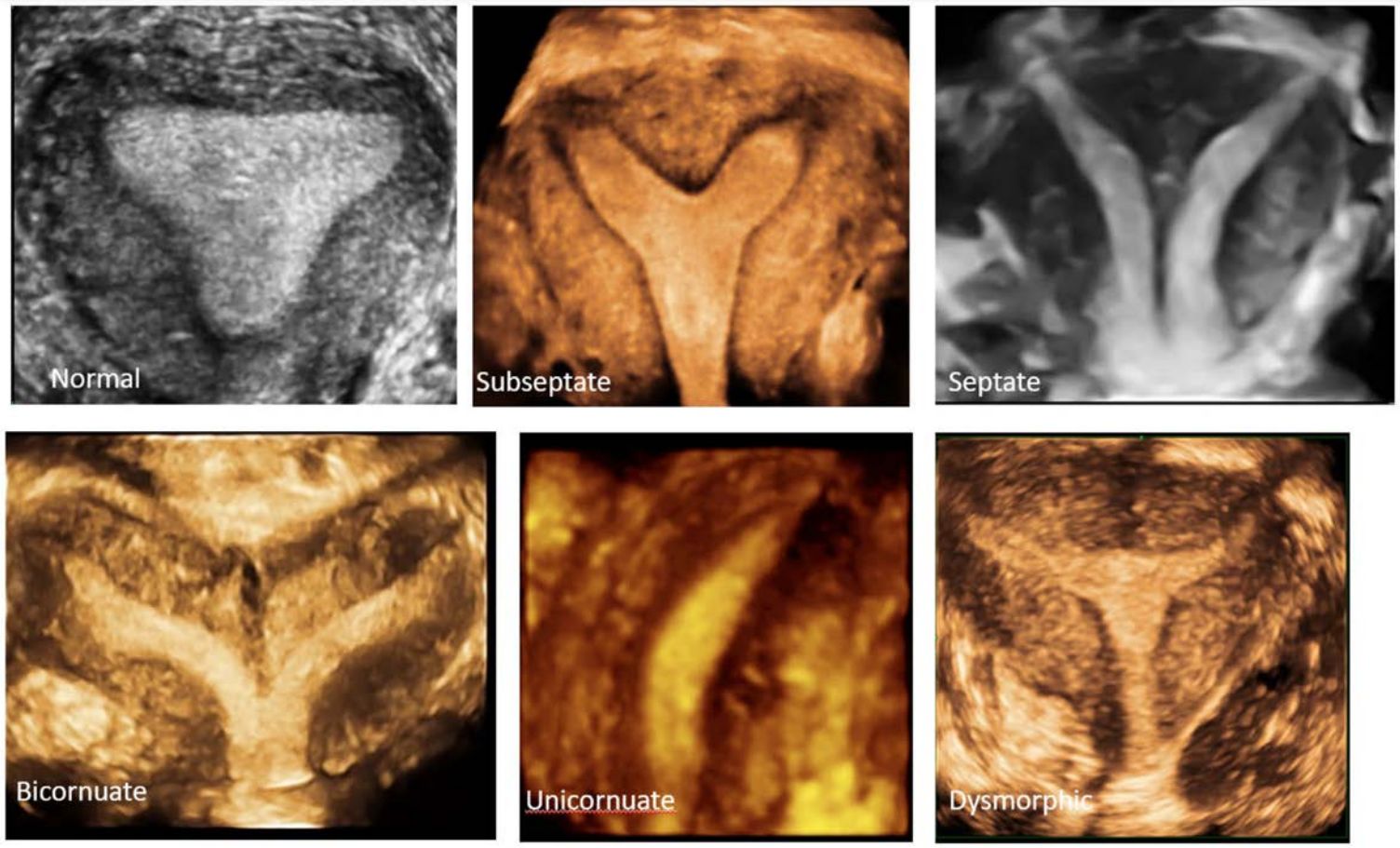


Hysterosalpingogram showing acute angle in a septate uterus (A) and wider angle in a bicornuate uterus (B)

Reproduced from: Jayaprakasan K, Ojha K. Diagnosis of Congenital Uterine Abnormalities: Practical Considerations. *Journal of Clinical Medicine*. 2022; 11(5):1251. https://doi.org/10.3390/jcm11051251

Chapter Outline

Anatomical Variants and Anomalies



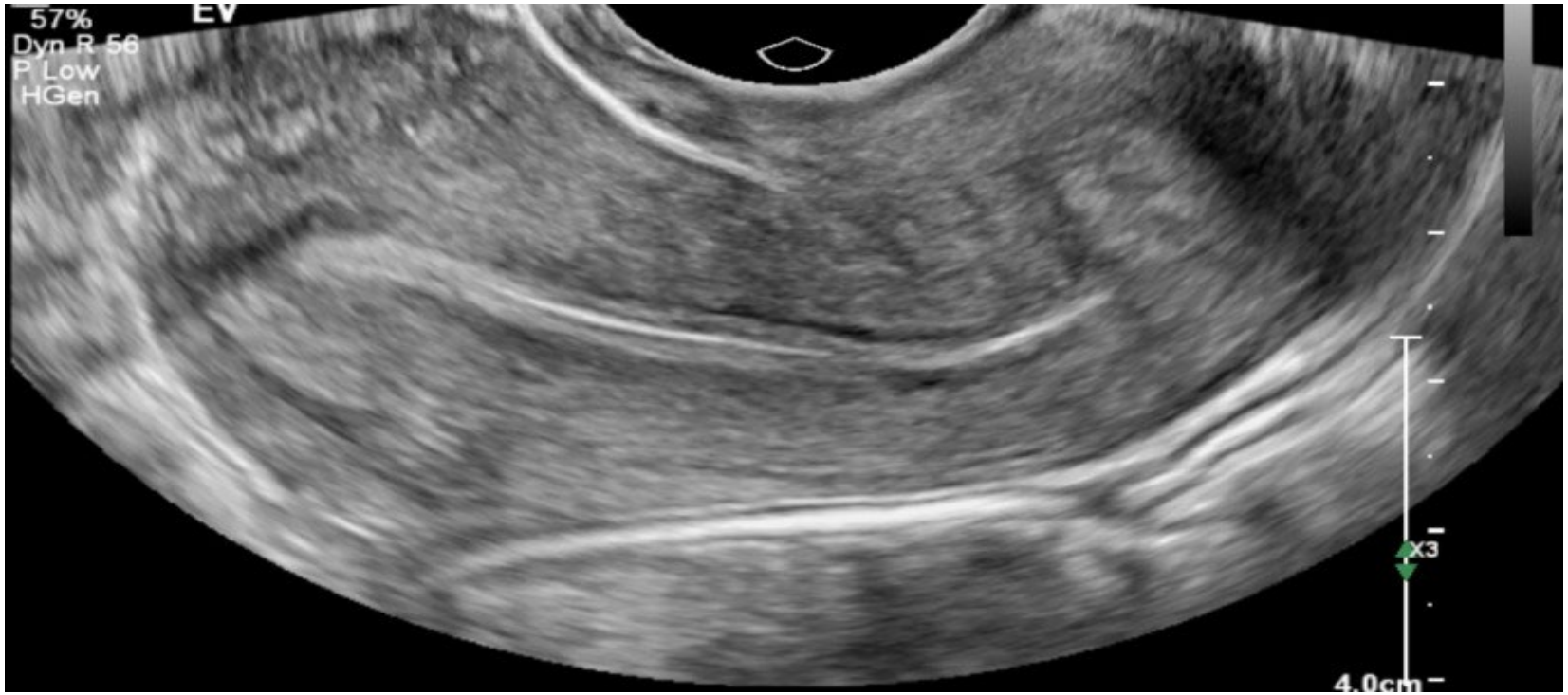
3D coronal plane of uterus: normal uterus, subseptate uterus, septate uterus, bicornuate, unicornuate uterus and dysmorphic (T-shaped) uterus.

Reproduced from: Jayaprakasan K, Ojha K. Diagnosis of Congenital Uterine Abnormalities: Practical Considerations. *Journal of Clinical Medicine*. 2022; 11(5):1251. https://doi.org/10.3390/jcm11051251

Chapter Outline

Anatomical Variants and Anomalies

Radiological Features: On ultrasound, the myometrium appears intermediate in echogenicity, with the endometrial echogenicity varying with the menstrual cycle. MRI provides detailed images of the uterus, especially useful for detecting fibroids, adenomyosis, and congenital malformations.



Transvaginal longitudinal view of a normal uterus that is anteverted. The Endometrium myometrium and serosa have a normal appearance.

Reproduced from: Narayanan M, Tafti D, Cohen HL. Pelvic Ultrasound. In: StatPearls. Treasure Island (FL): StatPearls Publishing; May 22, 2023.

Chapter Outline

Imaging Techniques in Gynaecological and Obstetric Evaluation

Ultrasound

Types:

- Transabdominal Ultrasound: Generally used for early pregnancy scans and larger pelvic structures.
- Transvaginal Ultrasound: A specially designed probe is inserted into the vagina. Offers more detailed images, especially in early pregnancy or to assess the ovaries and uterine lining.

Indications:

- First-line for pregnancy evaluation: fetal position, number, and viability.
- Measurement of fetal structures for age and anomaly assessments.
- Uterine and ovarian pathology examination: fibroids, cysts, and endometrial growths.
- Procedure guidance, like follicular monitoring or needle biopsies.

Diagnostic Value:

- Provides dynamic, real-time imaging.
- Absence of ionizing radiation makes it safe for fetuses and non-pregnant individuals.
- Economical and widely available.

Imaging Techniques in Gynaecological and Obstetric Evaluation

Ultrasound

Strengths:

- Non-invasive and painless: Doesn't require any needles or injections.
- Safe: No ionizing radiation, making it ideal for pregnant women and fetuses.
- Real-time imaging: Allows for dynamic assessment, such as fetal movements or blood flow.
- Portable and accessible: Can be used in varied settings, including rural areas or at the bedside.

Weaknesses:

- Operator dependent: Image quality can vary based on the sonographer's skill.
- Limited penetration: Less effective for deeper structures or in patients with increased body mass.
- Cannot visualize bones or air-filled structures effectively

Imaging Techniques in Gynaecological and Obstetric Evaluation

Computed Tomography (CT)

Indications:

- Not a first choice for pregnancy due to radiation but can be used if benefits outweigh risks.
- Evaluation of extensive pelvic masses and complex cysts.
- Staging of gynecological malignancies.
- Pre-operative assessments for intricate surgeries.

Diagnostic Value:

- High-resolution images suitable for viewing bone, soft tissue, and blood vessels simultaneously.
- Useful for surgical planning.
- Ionizing radiation limits its use, especially in pregnant women.

Imaging Techniques in Gynaecological and Obstetric Evaluation

Computed Tomography (CT)

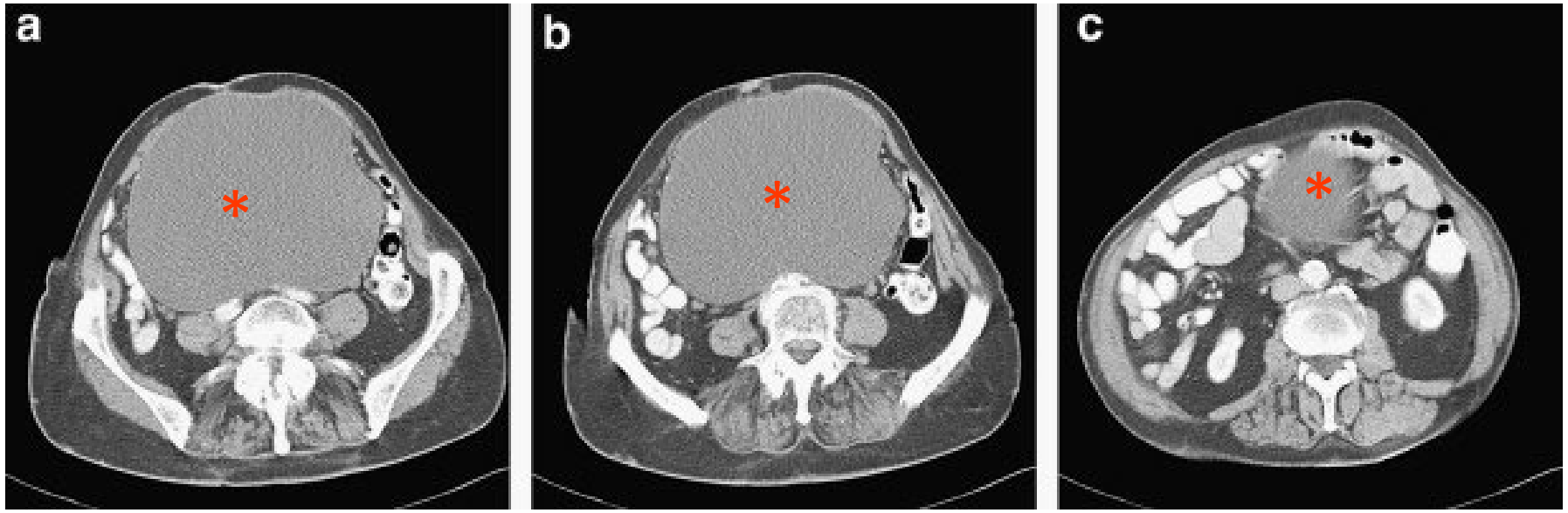
Strengths:

- High-resolution: Provides clear, detailed images.
- Speed: Fast imaging, which can be critical in emergencies.
- Versatility: Can image a wide range of body parts and conditions.
- 3D reconstruction: Allows for better visualization of complex structures.

Weaknesses:

- Radiation exposure: Not ideal for pregnant women unless absolutely necessary.
- Allergic reactions: Some patients may react to contrast agents.
- Less detailed for soft tissue differentiation: Compared to MRI

Simple Ovarian Cyst on Computed Tomography



Simple giant , purely cystic, unilocular ovarian cyst, consistent with a benign cyst with aortic compression. Note the absence of internal septations or solid components which are usually associated with complex lesions

Reproduced from: J. Timmermans et al. (2009) Aortic Thrombosis Due to a Giant Ovarian Cyst. EJVES Extra, 17(4), 33-35. https://doi.org/10.1016/j.ejvsextra.2008.11.010

Chapter Outline

Imaging Techniques in Gynaecological and Obstetric Evaluation

Magnetic Resonance Imaging (MRI)

Types
- Pelvic MRI: Standard MRI for detailed examination of gynecological concerns.
- Fetal MRI: Provides detailed images of the fetus, especially when ultrasound results are inconclusive.

Indications:
- Deep infiltrating endometriosis.
- Placental evaluations, such as placenta accreta.
- Detailed assessment of congenital uterine anomalies.
- Fibroid mapping before myomectomy.
- Further evaluation of complex adnexal masses when ultrasound is inconclusive.

Diagnostic Value:
- Exceptional soft tissue contrast, allowing differentiation between similar tissues.
- Can visualize structures in multiple planes.
- Does not involve ionizing radiation, making it safe during pregnancy.

Chapter Outline

Imaging Techniques in Gynaecological and Obstetric Evaluation

Magnetic Resonance Imaging (MRI)

Strengths:

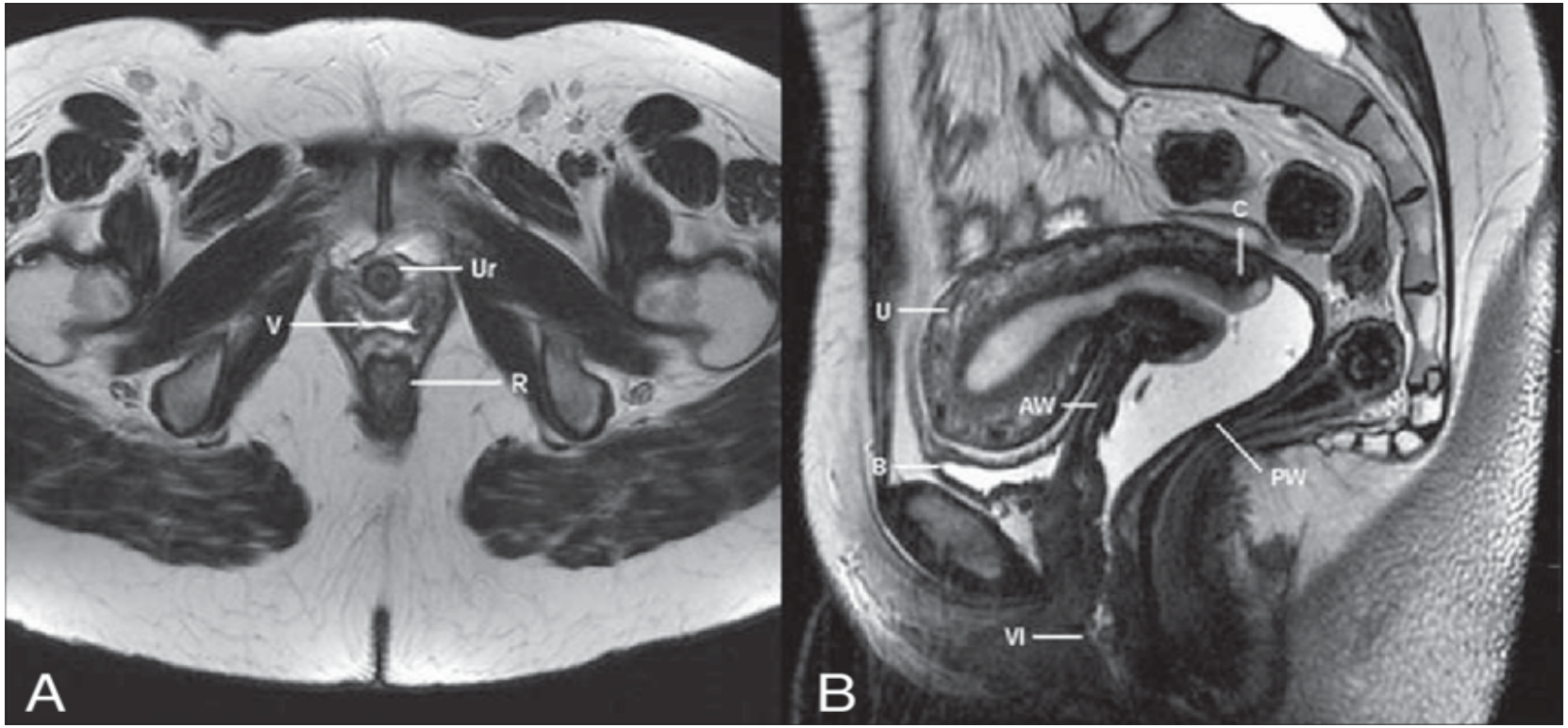
- Exceptional soft tissue contrast: Distinguishes between tissues that appear similar on other modalities.
- Multi-planar imaging: Can visualize structures in any plane without moving the patient.
- No ionizing radiation: Safe for most patients, including pregnant women.
- Functional imaging: Can assess tissue function, not just structure.

Weaknesses:

- Duration: MRI scans can take longer than other imaging techniques.
- Cost: Typically more expensive than CT or US.
- Noise: Can be uncomfortable due to loud noises during the scan.
- Contraindications: Not suitable for patients with certain implants, like some pacemakers

Chapter Outline

MRI of Normal Female Pelvis



Axial (A) and sagittal (B) MRI T2-weighted images showing the anterior compartment containing the urethral ostium (Ur) and the ostium of the bladder (B), the medial compartment containing the uterus (U), the uterine cervix (C), the vagina distended with gel (V), the anterior wall of the vagina (AW), the posterior wall of the vagina (PW), the vaginal vestibule (VI) and the posterior compartment with the rectum (R).

Reproduced from: Ferreira DM, Bezerra RO, Ortega CD, Blasbalg R, Viana PC, de Menezes MR, Rocha Mde S. Magnetic resonance imaging of the vagina: an overview for radiologists with emphasis on clinical decision making. Radiol Bras. 2015 Jul-Aug;48(4):249-59. doi: 10.1590/0100-3984.2013.1726. PMID: 26379324; PMCID: PMC4567364.

Chapter Outline

Ovarian Cysts

Ovarian cysts are fluid-filled sacs within the ovaries, encompassing several types based on their composition and origin.

Functional cysts, including follicular and corpus luteum cysts, form during the menstrual cycle and often resolve spontaneously.

Dermoid cysts, or mature teratomas, can contain various tissues such as hair, teeth, and fat.

Endometriomas are related to endometriosis and contain old blood and endometrial tissue. The characteristics of ovarian cysts vary; functional cysts are typically small and asymptomatic, while dermoid cysts and endometriomas may present more complex features and symptoms.

Cyst complications :

Cyst rupture:
Rupture of an ovarian cyst can lead to acute abdominal pain and, sometimes, internal bleeding. The pain is typically sudden and sharp.

Torsion:
Ovarian torsion occurs when the cyst becomes so large that it causes the ovary to twist around the ligaments that support it. This can lead to ischemia (restricted blood supply) and infarction (tissue death) of the ovary, causing severe pain and potentially affecting fertility.

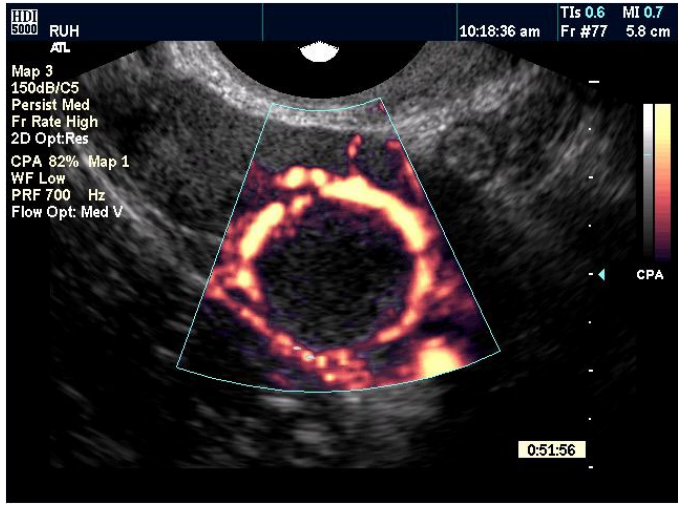
Hemorrhage:
Some cysts, particularly corpus luteum cysts, can bleed internally. Hemorrhaging cysts may cause pain and can lead to significant blood loss.

Chapter Outline

Ovarian Cysts: Ultrasound

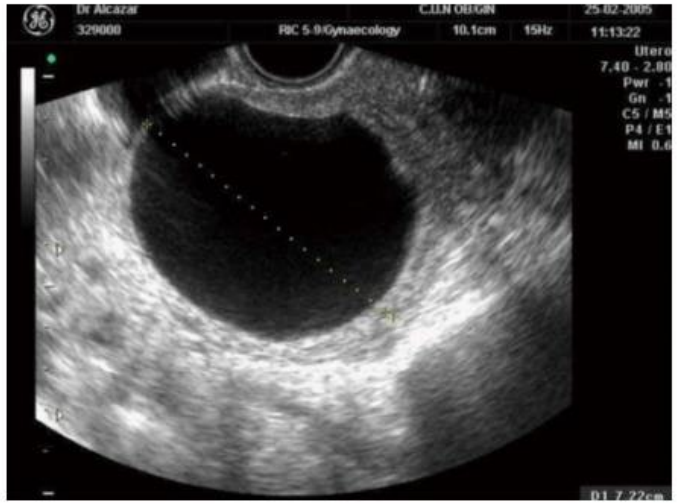
Functional Cysts:

- Follicular cysts appear as simple, anechoic structures with a thin wall and round or oval shape, usually larger than 3 cm.
- Corpus luteum cysts exhibit thick walls, can be hyperechoic, and may contain blood or serous fluid, giving them mixed echogenicity. Circumferential blood flow, seen during Doppler ultrasound, is a distinguishing feature, sometimes referred to as the 'ring of fire.'



Power flow Doppler image of a mature, mid-cycle luteal gland demonstrating marked periluteal vascular flow.

Reproduced from: Transvaginal ultrasonography and female infertility | GLOWM. (n.d.). Retrieved January 27, 2024, from https://www.glowm.com/section-view/heading/Transvaginal%20ultrasonography%20and%20female%20infertility/item/325#



Transvaginal ultrasound showing an ovarian simple cyst as a round anechoic thin-walled cyst with no irregularity on the internal wall measuring >7cm

Reproduced from: Alcazar JL et al. Ovarian simple cysts in asymptomatic postmenopausal women detected at transvaginal ultrasound: A review of literature. *World J Obstet Gynecol* 2015; 4(4): 108-112 DOI: 10.5317/wjog.v4.i4.108

Chapter Outline

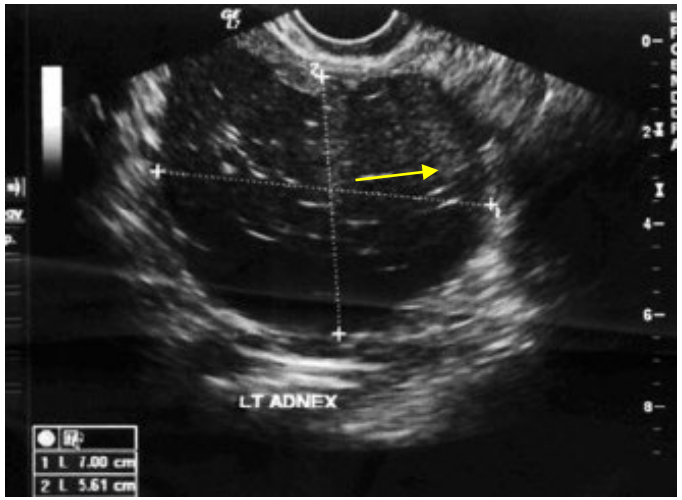
Ovarian Cysts: Ultrasound

Dermoid Cysts (Mature Cystic Teratomas):

Present with complex features due to multiple tissue types, including echogenic elements for fat and hair, and possibly a Rokitansky nodule. The "dermoid mesh" is a sonographic feature of ovarian dermoid cysts, characterized by echogenic lines representing hair within the cyst

Endometriomas:

Typically manifest as homogeneous cysts with low-level internal echoes "ground-glass" , also known as "chocolate cysts."



Transvaginal ultrasound showing dermoid cyst with the characteristic dermoid mesh.(yellow Arrow)

Reproduced from: Shetty NS et al. Unreported location and presentation for a parasitic ovarian dermoid cyst in an indirect inguinal hernia. Hernia. 2013;17(2):263-265. doi:10.1007/s10029-011-0876-z

Endometrioma with the ground-glass appearance

Reproduced from: Manero, M.G., Royo, P., Olartecoechea, B. et al. Endometriosis in a postmenopausal woman without previous hormonal therapy: a case report. J Med Case Reports 3, 135 (2009). https://doi.org/10.1186/1752-1947-3-135

Chapter Outline

Ovarian Cysts: CT

Functional Cysts:

- Can be identified as well-circumscribed, low-density lesions without significant enhancement, except in the case of corpus luteum cysts, which may show wall enhancement.

Dermoid Cysts:

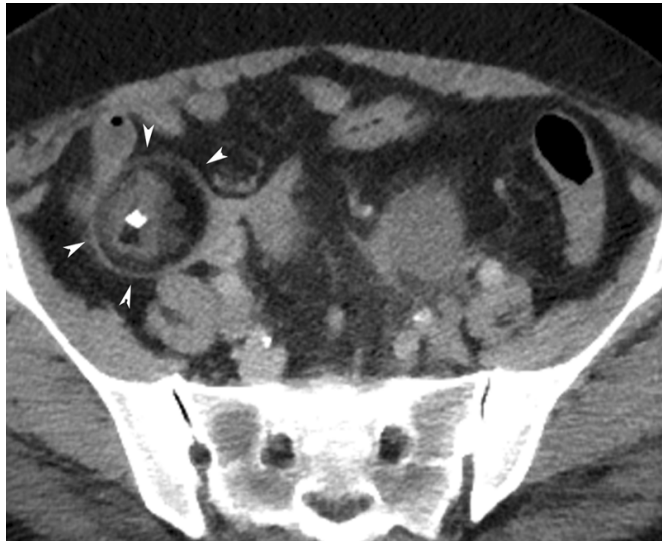
- Display fat attenuation and may have calcifications, illustrating their complex composition

Endometriomas:

- While CT is not the primary modality for these lesions, they may appear as cystic masses with higher attenuation due to their hemorrhagic content

Typical appearance of an uncomplicated corpus luteum in the second half (luteal phase) of the menstrual cycle on axial CT images: the normal-sized right ovary (arrowhead) contains a 1.5-cm cystic structure demarcated by a crenulated, strongly enhancing peripheral rim (arrow).

Reproduced from:Tonolini, M., Foti, P.V., Costanzo, V. et al. Cross-sectional imaging of acute gynaecologic disorders: CT and MRI findings with differential diagnosis—part I: corpus luteum and haemorrhagic ovarian cysts, genital causes of haemoperitoneum and adnexal torsion. Insights Imaging 10, 119 (2019). https://doi.org/10.1186/s13244-019-0808-5



Axial contrast-enhanced CT image shows a mature cystic teratoma and rounded Rokitansky nodule (arrowheads) made up of fat and a tooth-like structure in a high-density cystic mass.

Reproduced from: Sahin H, Abdullazade S, Sanci M. Mature cystic teratoma of the ovary: a cutting edge overview on imaging features. Insights Imaging. 2017 Apr;8(2):227-241. doi: 10.1007/s13244-016-0539-9. Epub 2017 Jan 19. PMID: 28105559; PMCID: PMC5359144.

Chapter Outline

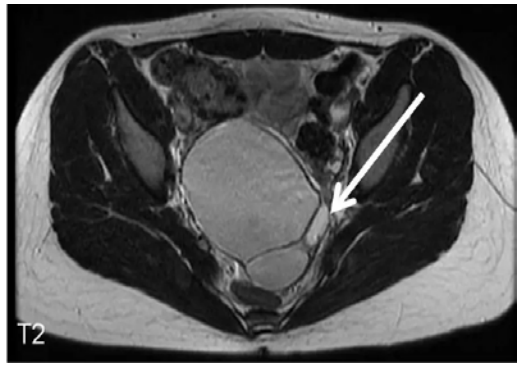
Ovarian Cysts: MRI

Functional Cysts:

- Appear hyperintense on T2-weighted images.
- Generally, hypointense on T1-weighted images unless they have hemorrhagic content.

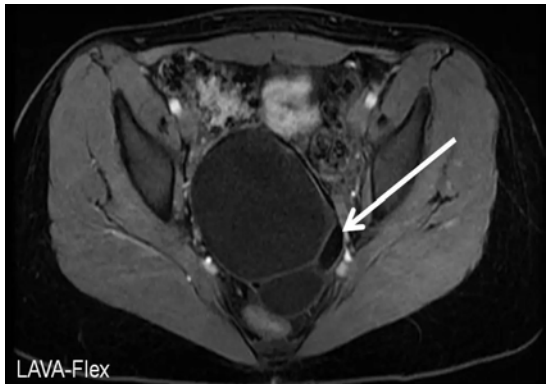
Dermoid Cysts:

- Exhibit variable signal intensities on both T1 and T2-weighted images.
- This variability is due to their heterogenous content, which can include fat, sebaceous material, hair, and calcifications

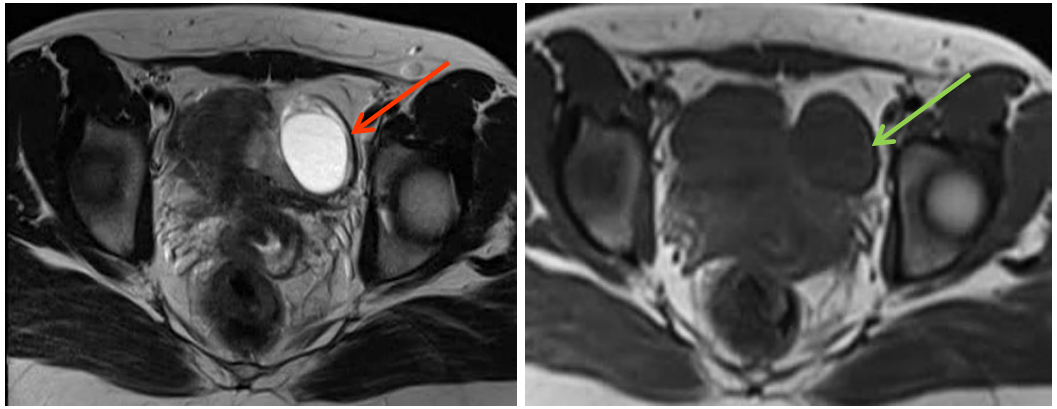


Axial T2W MRI demonstrates a pelvic cystic structure containing fat (white arrow) as indicated by the signal corresponding to that of the subcutaneous fat

Reproduced from: https://radiologypics.com/2014/03/19/ovarian-dermoid-cyst-mri/ , Last accessed on 01 Jan 2024



Axial LAVA-Flex (T1W 3D GRE (LAVA) with 2-point Dixon fat/water separation) MRI demonstrates a pelvic cystic structure containing fat (white arrow) as indicated by the signal corresponding to that of the subcutaneous fat.

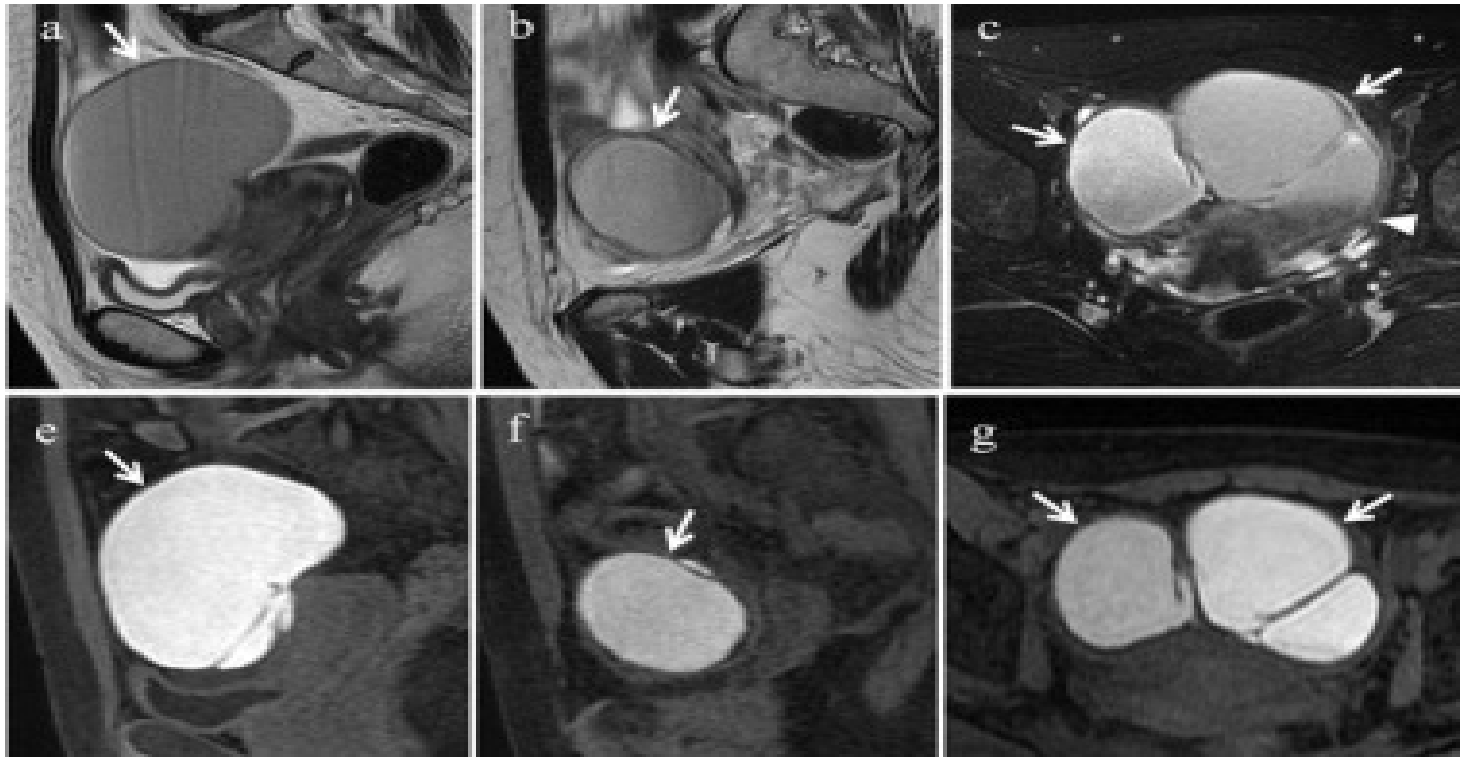


Axial T2W MRI demonstrates a T2-WI hyperintense ovarian cyst. The cyst is hypointense on T1W MRI.
Case courtesy of Shailaja Muniraj, Radiopaedia.org, rID: 49380

Chapter Outline

Ovarian Cysts: MRI

Endometriomas:
The criteria to identify endometriomas on MRI include the presence of numerous cysts that are bright on T1 sequences OR at least one cyst that not only shows high T1 signal intensity but also displays a gradient of intensity on T2 sequences, often described as "shading."



(a, b) Sagittal, (c) oblique axial T2-weighted images show bilateral endometriomas with intermediate to low signal intensity (white arrows). The ovaries are joined together behind the uterus (kissing ovaries). Note the low signal intensity in the declivous portion of the left cyst ("shading" sign, white arrowhead in c). On (e, f) sagittal and (g) oblique axial fat-suppressed T1-weighted images the cysts demonstrate high signal intensity (white arrows)

Reproduced from: Foti PV, Farina R, Palmucci S, Vizzini IAA, Libertini N, Coronella M, Spadola S, Caltabiano R, Iraci M, Basile A, Milone P, Cianci A, Ettorre GC. Endometriosis: clinical features, MR imaging findings and pathologic correlation. Insights Imaging. 2018 Apr;9(2):149-172. doi: 10.1007/s13244-017-0591-0. Epub 2018 Feb 15. PMID: 29450853; PMCID: PMC5893487.

Chapter Outline

Uterine Fibroids (Leiomyomas)

Uterine fibroids, or leiomyomas, are benign growths originating from the smooth muscle tissue of the uterus. They are categorized into several types based on their location within the uterus.

Sub-serosal fibroids: These fibroids develop on the outer surface of the uterus and may grow outward, potentially causing pressure on adjacent organs, such as the bladder or rectum.

Intramural fibroids: Intramural fibroids are located within the muscular wall of the uterus. They can lead to uterine enlargement and distortion, often causing heavy menstrual bleeding and pelvic pain.

Submucosal fibroids: Submucosal fibroids protrude into the uterine cavity and can significantly affect fertility by interfering with implantation or causing recurrent miscarriages.

Uterine fibroids are hormonally responsive and often grow during reproductive years. Their size can vary from small nodules to large masses, with symptoms ranging from heavy menstrual bleeding to pelvic pressure and pain.

Chapter Outline

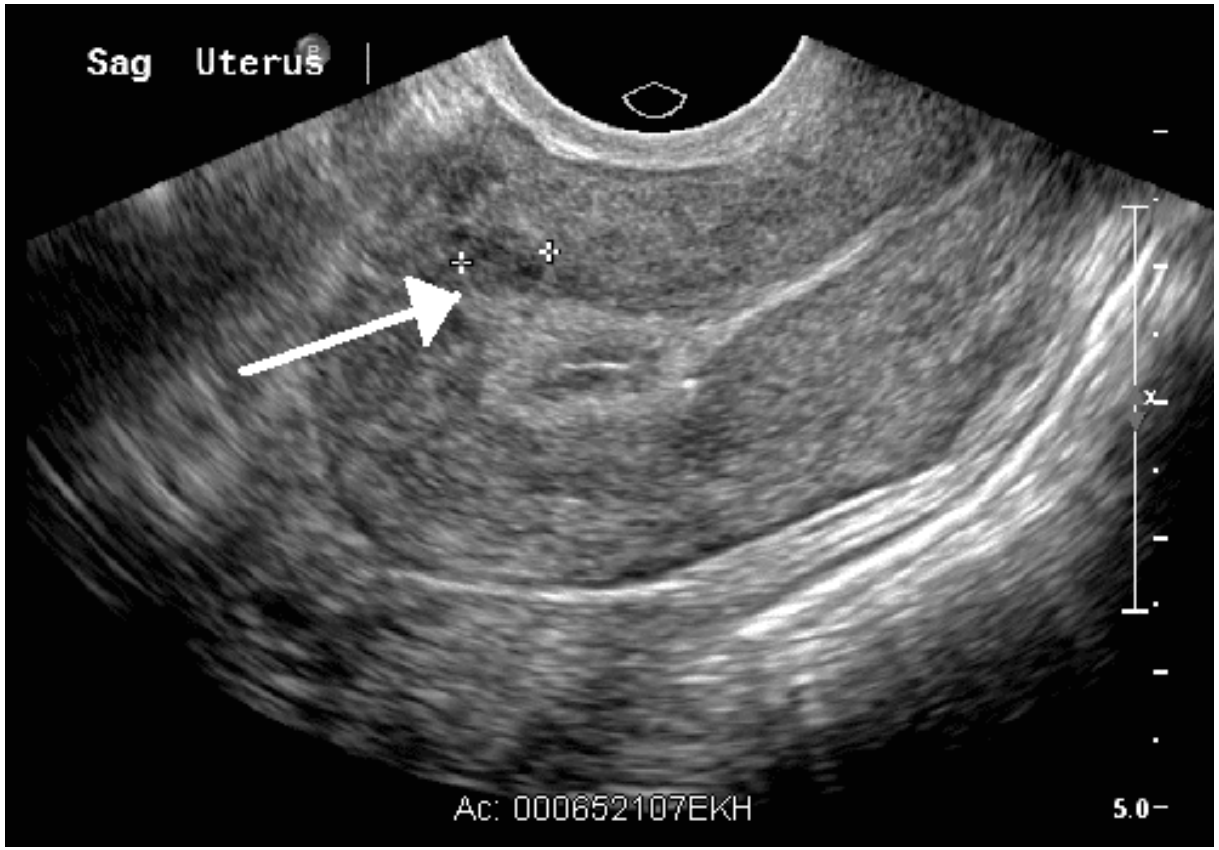
Uterine Fibroid: Ultrasound

Uterine fibroids appear as well-defined, hypoechoic (darker) masses.

Subserosal fibroids may be observed on the uterine surface, intramural fibroids within the uterine wall, and submucosal fibroids projecting into the uterine cavity. Their echogenicity can vary depending on their composition.

Larger fibroids may have a heterogeneous texture due to degenerative changes.

Calcified fibroids present with acoustic shadowing



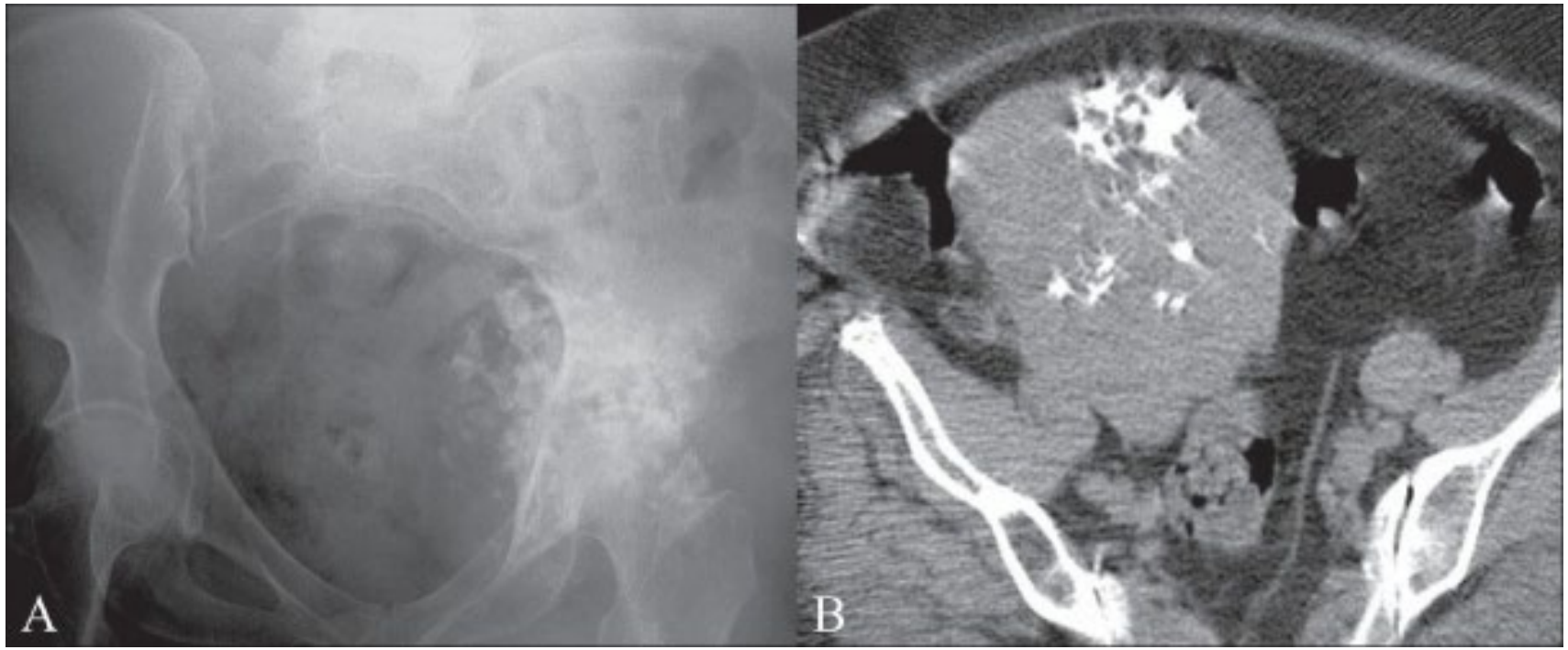
A hypoechoic intramural fibroid on pelvic ultrasound.

Reproduced from: James Heilman, MD, https://en.wikipedia.org/wiki/File:UterineFirboid.png

Chapter Outline

Uterine Fibroid: CT

Uterine fibroids may be incidentally detected on CT as well-circumscribed, low-density lesions within the uterine wall. CT is not the primary modality for fibroid evaluation but may show their presence. Fibroids may not be distinguishable from the normal myometrium on non-contrast scans



A 58-year-old woman with sacral pain. A frontal pelvic radiograph (A) shows calcification overlying the left hip, initially thought to be suggestive of a chondrosarcoma. A subsequent CT scan (B) reveals an incidental calcified fibroid

Reproduced from: Wilde, S., & Scott-Barrett, S. (2009). Radiological appearances of uterine fibroids. The Indian journal of radiology & imaging, 19(3), 222–231. https://doi.org/10.4103/0971-3026.54887

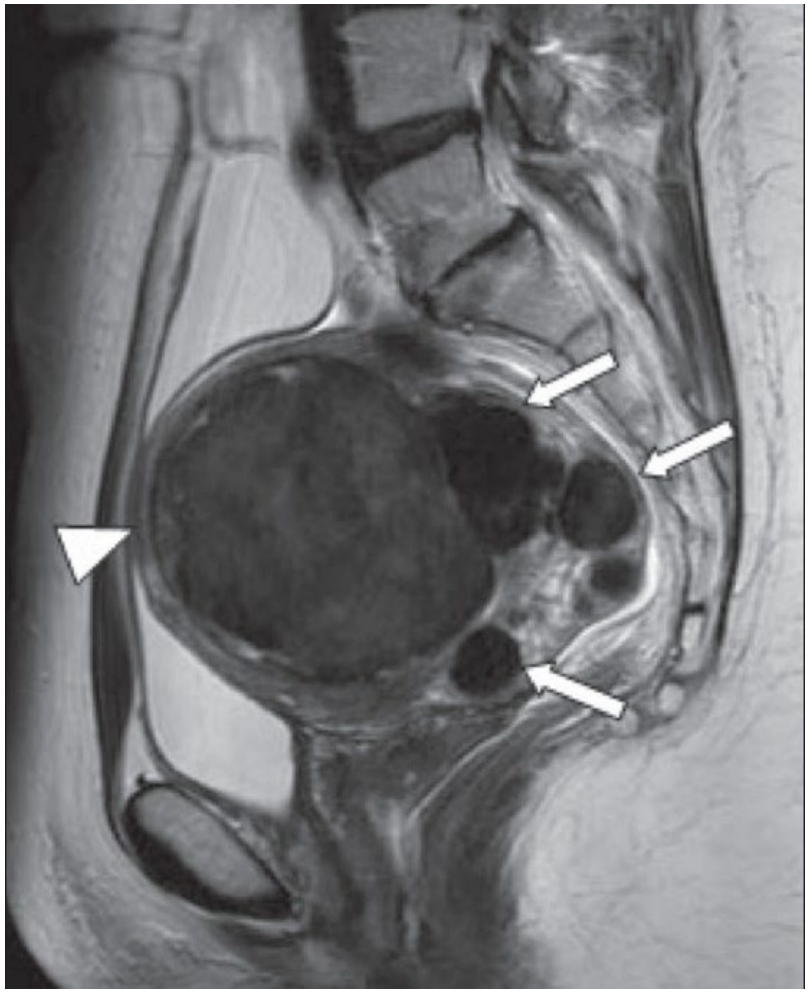
Chapter Outline

Uterine Fibroid: MRI

Uterine fibroids appear as well-defined masses with low signal intensity on T2-weighted images.

Degenerating fibroids may have varied signal intensity and may show enhancement after contrast administration.

MRI is superior for assessing the number, size, and location of fibroids, critical for surgical planning.



Sagittal T2W MRI image shows multiple intramural fibroids (arrows); the largest (arrowhead) lying anteriorly measures 8.5 cm. These show typical low-signal intensity

Reproduced from: Wilde, S. et al. (2009). Radiological appearances of uterine fibroids. *The Indian journal of radiology & imaging*, *19*(3), 222–231. https://doi.org/10.4103/0971-3026.54887

Chapter Outline

Endometriosis

Endometriosis is a chronic condition characterized by the presence of tissue similar to the uterine lining outside the uterus, often involving various pelvic structures.

There are different types of Endometriosis:

- Superficial endometriosis: it involves the peritoneal surface, where endometrial-like tissue forms small lesions or adhesions.
- Ovarian Endometriosis (endometriomas): also known as chocolate cysts or endometriotic cysts (see age 34)
- Deep infiltrating endometriosis (DIE): DIE extends into pelvic organs, such as the rectovaginal septum, bladder, or bowel, creating nodular lesions or thickening of tissues. DIE is defined as endometriosis lesions with a depth of more than 5 mm.

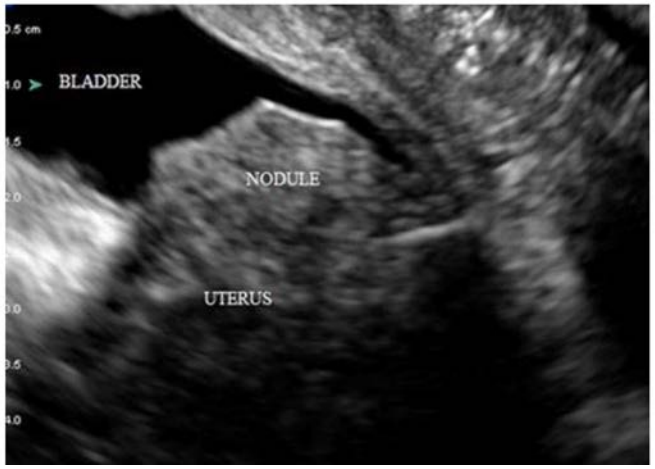
Endometriosis lesions can vary in size and severity, causing symptoms such as pelvic pain, dysmenorrhea, dyspareunia, and infertility. The condition may be hormonally responsive.

Chapter Outline

Endometriosis: Ultrasound

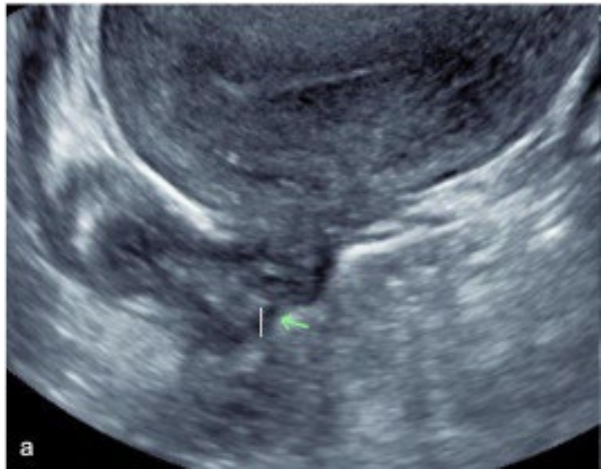
Superficial endometriosis may not be easily visualized on ultrasound. Endometriosis nodules typically present on ultrasound as solid, irregularly shaped masses with low echogenicity, possibly featuring echogenic spots or tiny cysts, they usually exhibit minimal to no vascular signal on color Doppler imaging..

Studies have demonstrated that when a transvaginal ultrasound is expanded to evaluate not just the uterus and ovaries but also the anterior and posterior regions, its accuracy in identifying deep endometriosis exceeds 90%.



Deep infiltrating endometriosis (DIE) nodule of the bladder appearing as a protrusive nodule arising from the bladder base towards the lumen of the bladder

Reproduced from: Daniilidis, A. et al. (2022). Transvaginal Ultrasound in the Diagnosis and Assessment of Endometriosis-An Overview: How, Why, and When. Diagnostics (Basel, Switzerland), 12(12), 2912. https://doi.org/10.3390/diagnostics12122912



Transvaginal ultrasound image of 35-year-old female with pelvic pain and history of endometriosis, showing typical hypoechoic endometriotic nodule (arrow) invading two segments of the rectosigmoid with hyperechoic rim (Arrowhead).

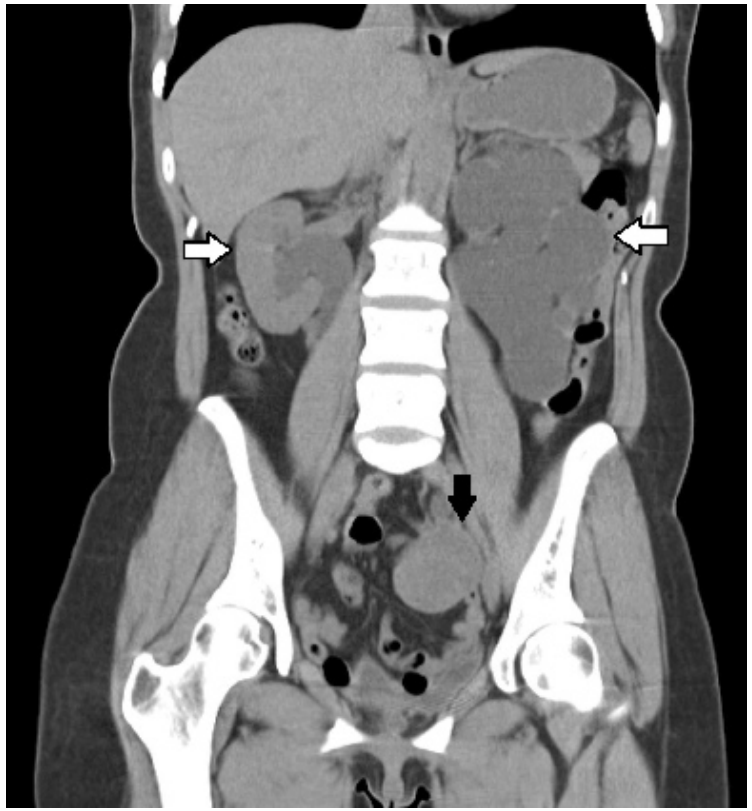
Reproduced from: Khatri, G. D et al. (2023). Rectal endometriosis imaging: A case based pictorial essay. WFUMB Ultrasound Open, 1(1), 100002. https://doi.org/10.1016/J.WFUMBO.2023.100002

Chapter Outline

Endometriosis: CT

As CT of the pelvis does not visualize pelvic organs well, it is not useful in the diagnosis of endometriosis.

An important role for the CT scan with contrast is to detect ureteral involvement and possible renal insufficiency.



Pelvic CT (computed tomography) showed 4.5 cm sized left adnexal mass (black arrow in (a)) abutting with and obstructing the left distal ureter, resulting in severe left hydroureteronephrosis with complete loss of the left renal parenchyma; it also showed right mild hydroureteronephrosis without definite obstructive lesion (white arrows in (a) and (b)

Reproduced from :Charatsi, D. et al. (2018). Gastrointestinal and Urinary Tract Endometriosis: A Review on the Commonest Locations of Extrapelvic Endometriosis. Advances in medicine, 2018, 3461209. https://doi.org/10.1155/2018/3461209

Chapter Outline

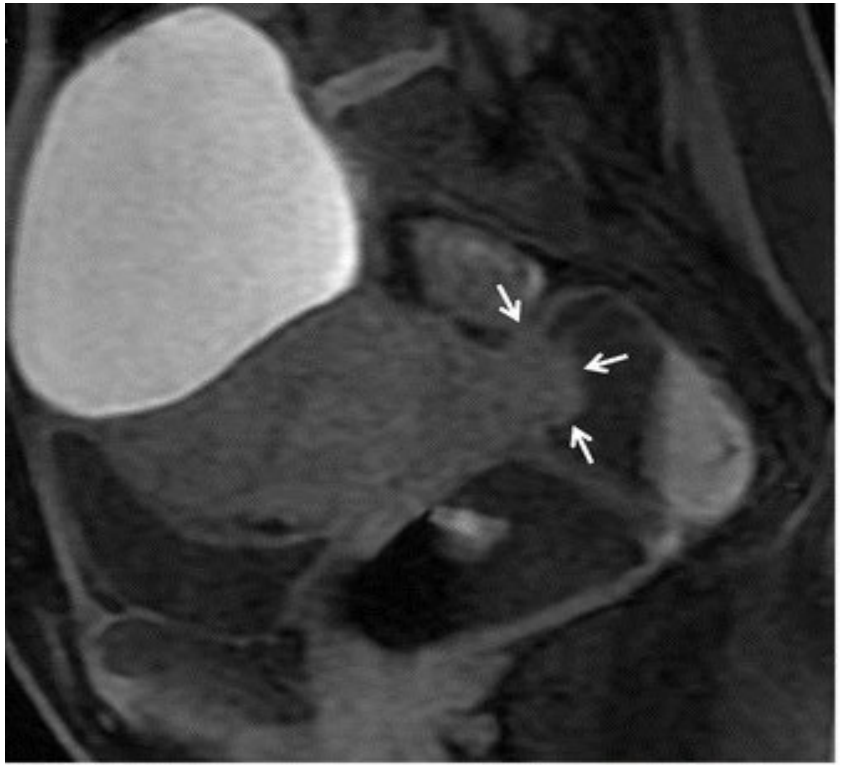
Endometriosis: MRI

Characteristic hemorrhagic lesions: These lesions, often referred to as "powder burn" due to their appearance, display a pronounced brightness on T1 fat-saturated MRI sequences.

Solid deep lesions: On MRI, they typically show increased signal intensity on T1 sequences and decreased intensity on T2 sequences.

Tissue adhesions and scarring: On MRI, these present with a signal intensity that matches the pelvic muscles on both T1 and T2 sequences. They can lead to:

- Fine, low-intensity strands that blur the delineation between organs.
- Anatomical alterations, backward shift of the uterus, ovaries in close proximity in advanced stages (commonly referred to as the "kissing ovaries" sign), misalignment of bowel segments, and upward shift of the posterior part of the vaginal cavity.
- Pockets of trapped fluid and the presence of fluid-filled fallopian tubes, known as hydrosalpinx.



Deep infiltrating endometriosis Sagittal fat-suppressed T1-weighted image shows an endometriotic nodule (white arrows) infiltrating the muscular layer of the anterior rectal wall. The lesion displays homogeneous intermediate signal intensity due to fibrous tissue and smooth muscle

Reproduced from: Foti, P. V. et al. (2018). Endometriosis: clinical features, MR imaging findings and pathologic correlation. Insights into imaging, 9(2), 149–172. https://doi.org/10.1007/s13244-017-0591-0

Chapter Outline

Ovarian Torsion

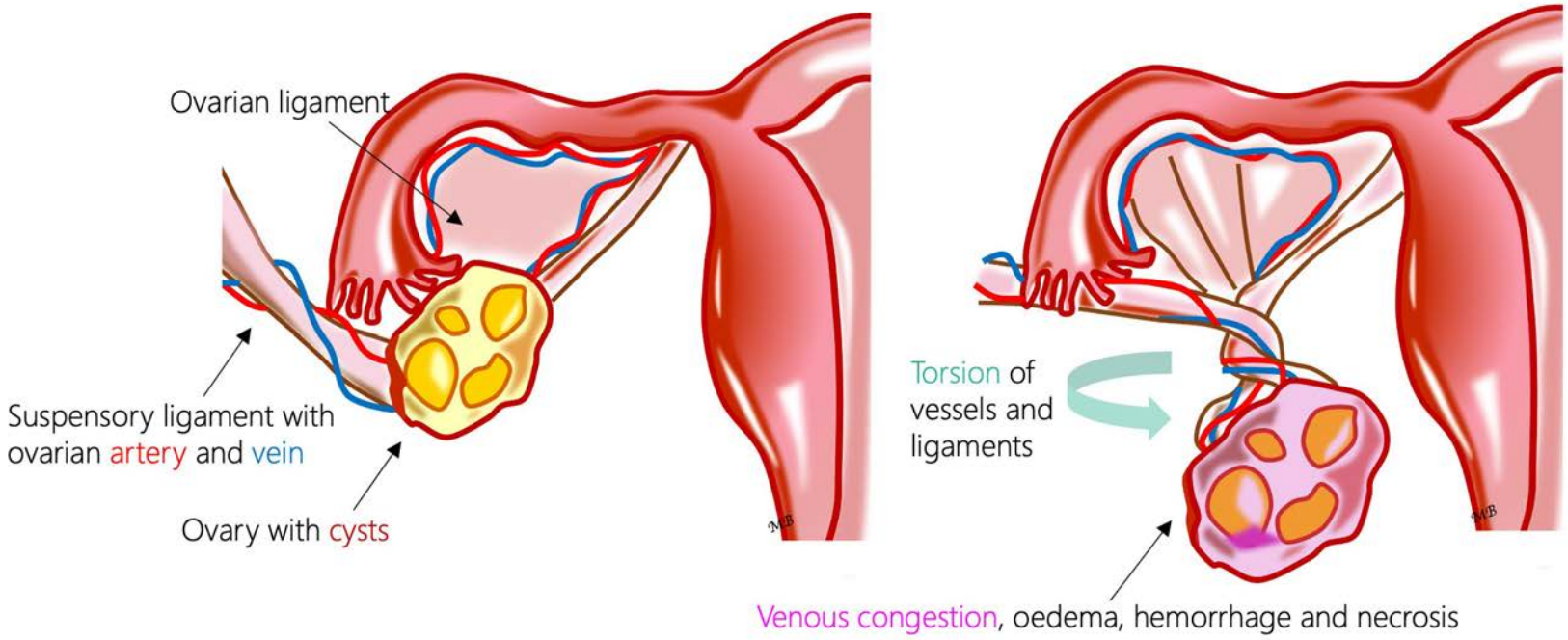
Ovarian torsion is a critical condition that often presents as an acute gynecological emergency.

It is caused by partial or complete rotation of the ovary on its ligamentous supports, potentially leading to occlusion of the ovarian artery and vein. This can result in ischemia and infarction of the ovary and, if not promptly addressed, may lead to loss of ovarian function.

Ovarian torsion is frequently associated with the presence of ovarian cysts or masses, which can act as a fulcrum for the rotation.

Clinical Presentation:

Patients with ovarian torsion often present with sudden, severe pelvic pain, sometimes accompanied by nausea and vomiting. The pain may be intermittent or constant and is typically unilateral.



Chapter Outline

Ovarian Torsion: Ultrasound

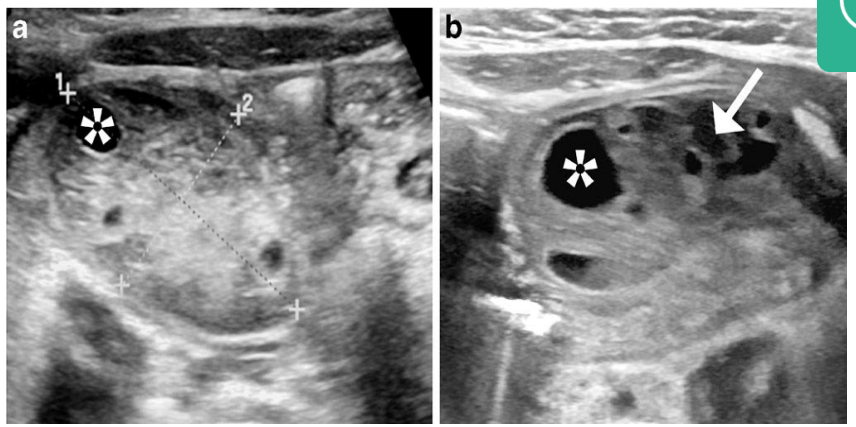
Ultrasound, often the initial diagnostic tool in assessing acute pelvic pain, presents variable sensitivity and specificity in detecting torsion. Transvaginal ultrasonography (TVUS) provides superior visualization of the ovaries, allowing for a more detailed evaluation of ovarian vascularity, the presence of a twisted vascular pedicle, and a clearer characterization of any adnexal masses.

Ovarian Morphology and Positioning:

The ovary typically presents with marked enlargement due to edematous changes, with follicles characteristically arrayed along the periphery along with hyperechoic margin(follicular ring sign). This displacement is a response to the central stromal swelling that pushes the follicles outward.

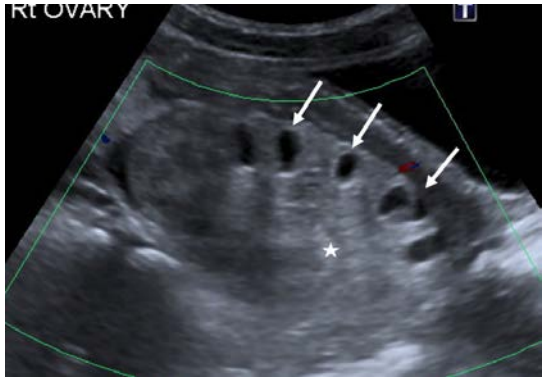
Vascular and Tissue Characteristics:

The ovarian stroma appears abnormally echogenic as a result of edema, and Doppler US imaging may reveal a complete or partial absence of both arterial and venous flow, suggesting a compromised blood supply.



The initial US of the lower abdomen in a pre-pubertal girl shows an enlarged ovary (calipers) with peripheral follicles (asterisk), consistent with an ovarian torsion. b Follow-up some days later in the same girl as in (a) shows cystic ovarian compartments (asterix) with sedimented echoes (arrow) indicating progressive hemorrhagic infarction.

Reproduced from: Riccabona, M. et al . (2017). European Society of Paediatric Radiology abdominal imaging task force recommendations in paediatric uroradiology, part IX: Imaging in anorectal and cloacal malformation, imaging in childhood ovarian torsion, and efforts in standardising paediatric uroradiology terminology. Pediatric Radiology, 47(10), 1369–1380. https://doi.org/10.1007/S00247-017-3837-6/FIGURES/12



Ultrasound image of the right ovary demonstrates enlargement, overall reduced Doppler signal, peripherally displaced follicles (white arrows) and echogenic central stroma (white star), consistent with ovarian torsion.

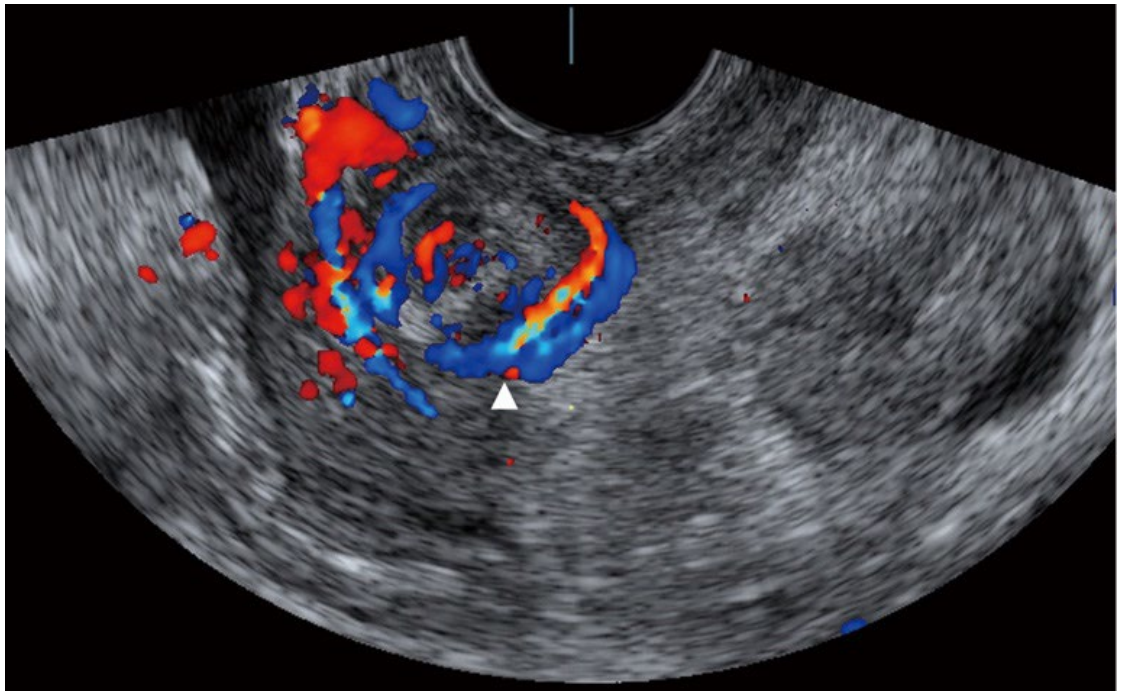
F. C. Daley, J. Smith, A. Shakur, P. L. Moyle, H. C. Addley, S. Freeman. Twists and turns of the female pelvis' – a pictorial review of adnexal torsion https://dx.doi.org/10.1594/ecr2018/C-1373

Chapter Outline

Ovarian Torsion: Ultrasound

Whirlpool sign: On Doppler ultrasound, the twisted vascular pedicle often manifests as the 'whirlpool' sign—a hallmark feature indicating torsion. Additionally, the presence of an extraneous knot-like structure may represent the actual site of the twisted pedicle.

Secondary signs and symptomatic response: The presence of ascites and elicited probe tenderness during a transvaginal scan further supports the diagnosis. The tenderness is indicative of the acute inflammatory process set off by the torsion and the resultant pressure effects on adjacent pelvic structures.



Transvaginal sonogram with 3D render mode indicates a whirlpool sign. The whirlpool sign (▲) presents as coiled, twisted, or circular vessels on Doppler US.

Reproduced from: Feng, J. L., Zheng, J., Lei, T., Xu, Y. J., Pang, H., & Xie, H. N. (2020). Comparison of ovarian torsion between pregnant and non-pregnant women at reproductive ages: sonographic and pathological findings. Quantitative imaging in medicine and surgery, 10(1), 137–147. https://doi.org/10.21037/qims.2019.11.06

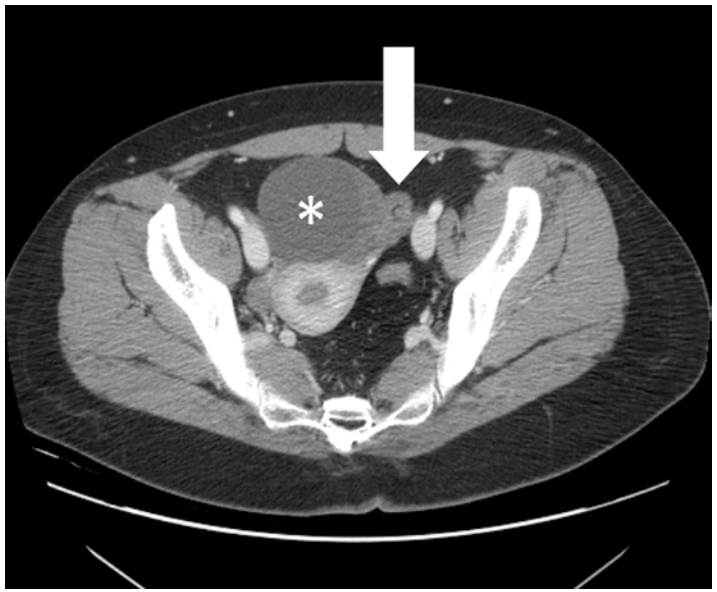
Chapter Outline

Ovarian Torsion: CT

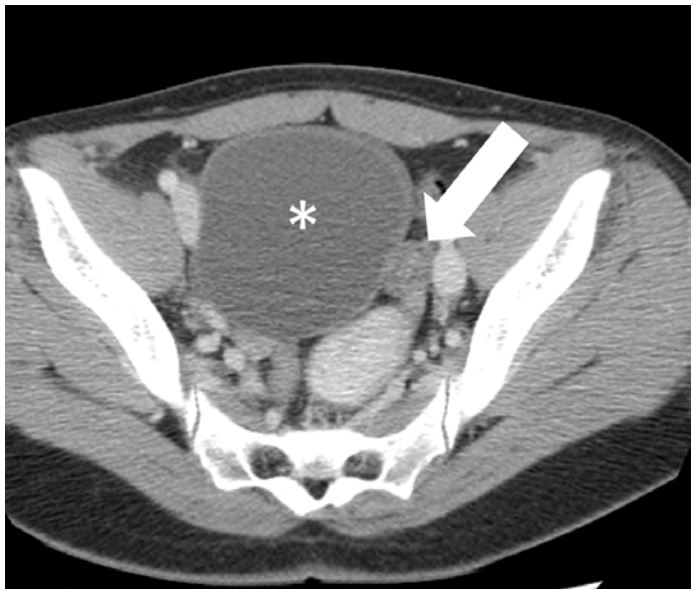
Ovarian Enlargement: The ovary typically appears homogeneously enlarged and may be deviated to the midline, a common sign of torsion.

Fat Stranding: The presence of fat stranding and free fluid in the adjacent pelvic area often indicates inflammation or haemorrhage secondary to torsion.

Twisted Vascular Pedicle: The CT hallmark of torsion is the visualization of a twisted ovarian pedicle. The appearance of this twisted pedicle on CT is considered pathognomonic for ovarian torsion, confirming the diagnosis.



woman with torsed left ovarian mature cystic teratoma. Axial contrast-enhanced CT scan shows a thickened pedicle (arrow) between a left ovarian cystic mass (asterisk) and the left uterine cornu with helical swirling appearance, suggestive of a whirl sign.



woman with torsed left ovarian mucinous cystadenoma. Axial contrast-enhanced CT scan shows a thickened pedicle (arrow) between the left uterine cornu and a pelvic mass (asterisk).

Reproduced from :Lee, M. S., Moon, M. H., Woo, H., Sung, C. K., Oh, S., Jeon, H. W., & Lee, T. S. (2018). CT findings of adnexal torsion: A matched case-control study. PLOS ONE, 13(7), e0200190. https://doi.org/10.1371/JOURNAL.PONE.0200190

Chapter Outline

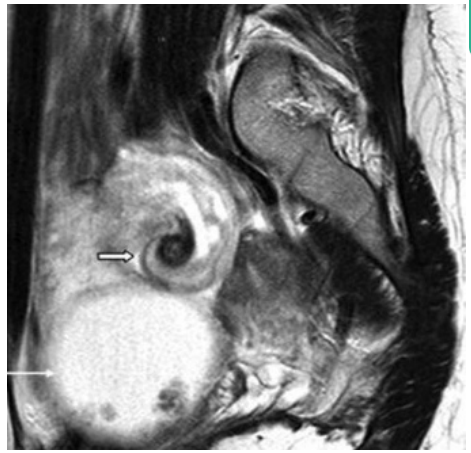
Ovarian Torsion: MRI

MRI is not the modality of choice for initial assessment of suspected ovarian, due to the need for expedited imaging. However, it can provide valuable information, particularly in complex cases.

Edema and Hemorrhage: T2-weighted imaging can reveal a hyperintense stroma, edema, while T1-weighted imaging can display a thin rim of high signal intensity characteristic of hemorrhagic infarction.

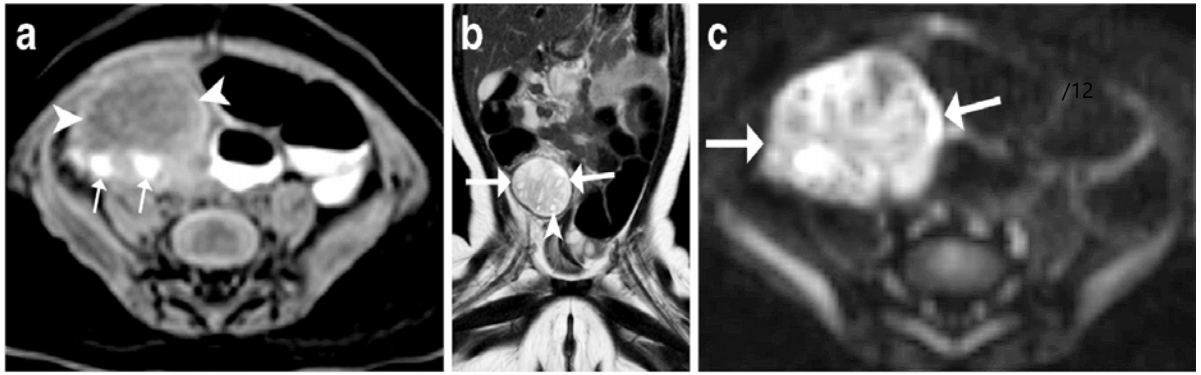
This rim of high signal is due to methemoglobin, which does not enhance with contrast, distinguishing it from endometriomas and hemorrhagic corpus luteal cysts that usually do not involve the entire ovary.

Vascular Flow: Despite not being the first-line imaging in acute settings, MRI can demonstrate the absence of blood flow within the twisted vascular pedicle, aiding in the confirmation of torsion.



T2-weighted, sagittal MR image showing "whirlpool appearance" of the right adnexa (thick arrow) suggestive of ovarian torsion. Right ovarian cystic mass is also seen (thin arrow)

Reproduced from: Ghonge, N. P., Lall, C., Aggarwal, B., & Bhargava, P. (2015). The MRI whirlpool sign in the diagnosis of ovarian torsion. Radiology case reports, 7(3), 731. https://doi.org/10.2484/rcr.v7i3.731



Typical appearance of ovarian torsion on MRI in a 4-month-old girl. a). Unenhanced axial T1-weighted fat-suppressed acquisition demonstrates hemorrhagic peripheral follicles (arrows) in the swollen and enlarged right ovary (arrowheads). b). Coronal T2-weighted image shows the enlarged right-side ovary (arrows) with small peripheral follicles (arrowhead). c). Axial diffusion-weighted image at b=1,000 demonstrates the diffusion impairment, inhomogenously distributed throughout the enlarged affected right ovary (arrows)

Reproduced from: Riccabona, M. et al . (2017). European Society of Paediatric Radiology abdominal imaging task force recommendations in paediatric uroradiology, part IX: Imaging in anorectal and cloacal malformation, imaging in childhood ovarian torsion, and efforts in standardising paediatric uroradiology terminology. Pediatric Radiology, 47(10), 1369–1380. https://doi.org/10.1007/S00247-017-3837-6/FIGURES

Chapter Outline

Endometrial Cancer

Endometrial cancer arises in the lining of the uterus (endometrium) and is one of the most common gynecological malignancies. Endometrial cancer is typically hormone-driven and often diagnosed in postmenopausal women. It may present with abnormal uterine bleeding, pelvic pain, or as an incidental finding.

The different types have varying histological features and clinical behaviors.

Types of endometrial cancer:

Endometrioid carcinoma: This is the most common type, often associated with estrogen exposure. It typically presents as an adenocarcinoma and is related to endometrial hyperplasia.

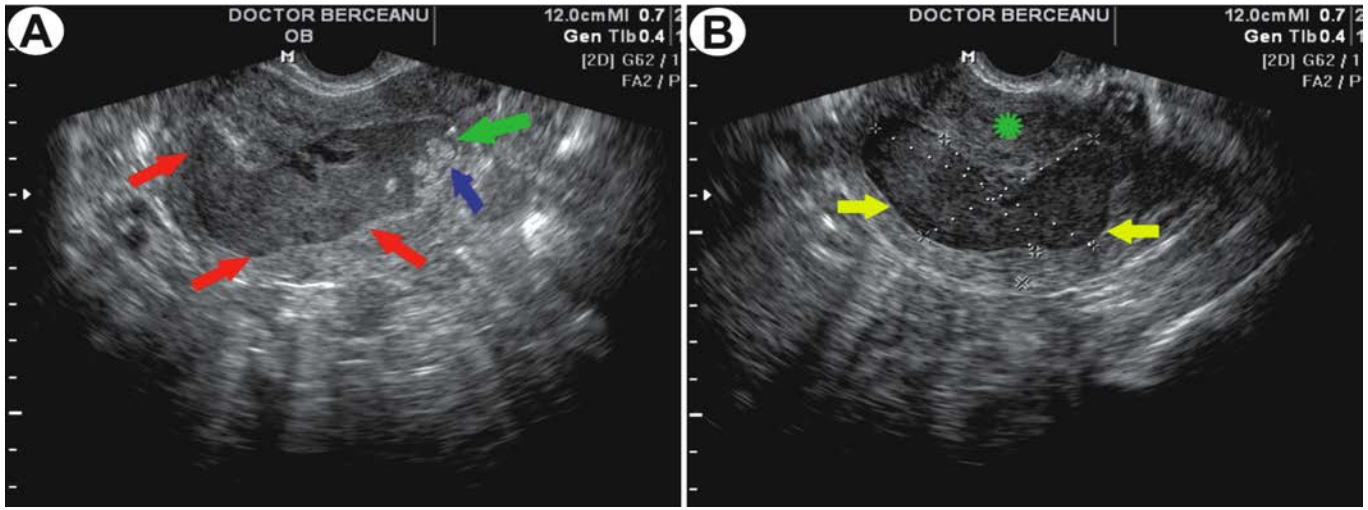
Serous carcinoma: Serous tumors are more aggressive and less common than endometrioid carcinomas. They are typically high-grade and may be associated with a worse prognosis.

Clear cell carcinoma: Clear cell carcinomas are characterized by clear cytoplasm and are less common. They often present at an advanced stage and have a poorer prognosis.

Chapter Outline

Endometrial Cancer: Ultrasound

On ultrasound, endometrial carcinoma typically manifests as endometrial thickening or a polypoid mass, with variation in premenopausal women depending on menstrual cycle timing and a threshold of over 5 mm (or 8 mm with hormone therapy) in postmenopausal women. Indicative sonographic features include irregular thickening, polypoid lesions, fluid collections, and potential myometrial invasion. A disrupted sub-endometrial halo may also suggest myometrial involvement. If transvaginal ultrasound is inconclusive, sono-hysterography with saline distension can provide a clearer evaluation of the endometrium.



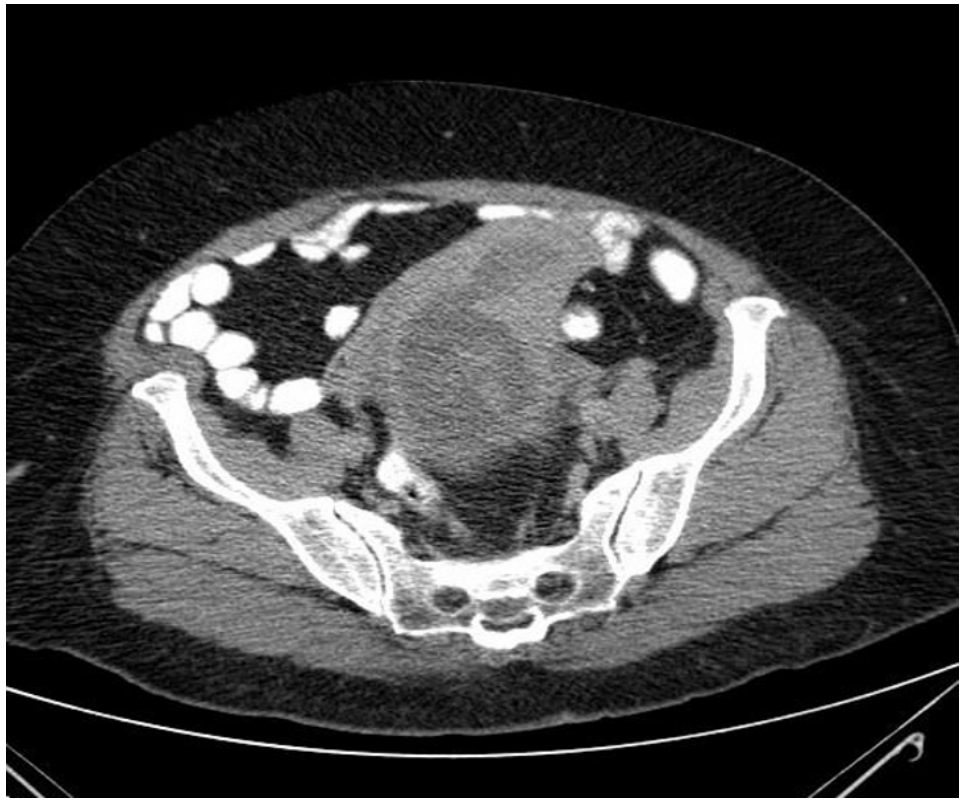
Endometrioid carcinoma:(A) Sagittal sonogram demonstrating severely enlarged uterine cavity (red arrows), heterogeneous echogenic mass (green arrow) on the rear wall of the uterine cavity, irregular outline, clear edges. Note hypoechogenic posterior band and the underlying formation (blue arrow) representing the peritumoral myometrium;(B) Sagittal sonogram demonstrating hematometra, with inhomogeneous, heterogeneous appearance, with anechogenic or hypoechogenic areas by tumor necrosis (yellow arrows). Note the intramural leiomyoma on the anterior uterine wall (green asterisk)

Reproduced from: Berceanu, C. et al. (2016). Morphological, imaging and surgical aspects in endometrial endometrioid adenocarcinoma. Romanian journal of morphology and embryology = Revue roumaine de morphologie et embryologie, 57(3), 995–1002.

Chapter Outline

Endometrial Cancer: CT

While limited in the initial diagnosis, CT is valuable for detecting metastatic spread, particularly in the lungs and liver, which are common sites for distant disease in advanced endometrial cancer. CT may show uterine enlargement or hypoattenuating mass with irregular endometrial thickening, especially in more advanced stages.



CT scan of the abdomen reveals a uterus (U) with dilated cavity (arrow) on top of the dilated cervix (C). surgical staging was completed by omentectomy and lymph node dissection. Histological examination of the specimens revealed grade I adenocarcinoma of the uterus located in the fundus with more than two thirds myometrial invasion

Reproduced from: Tannus, S., & Atlas, I. (2009). Endometrial cancer presenting as acute urinary retention: A case report and review of the literature. Cases Journal, 2(12), 1–3. https://doi.org/10.1186/1757-1626-2-9388/FIGURES/2

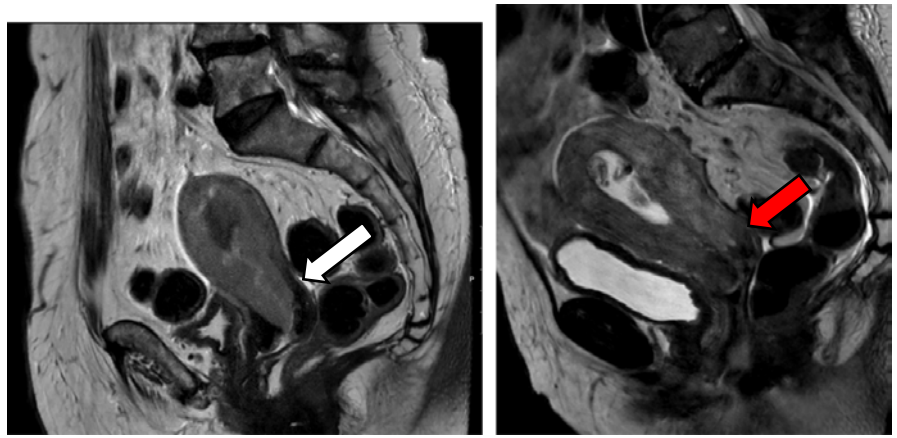
Chapter Outline

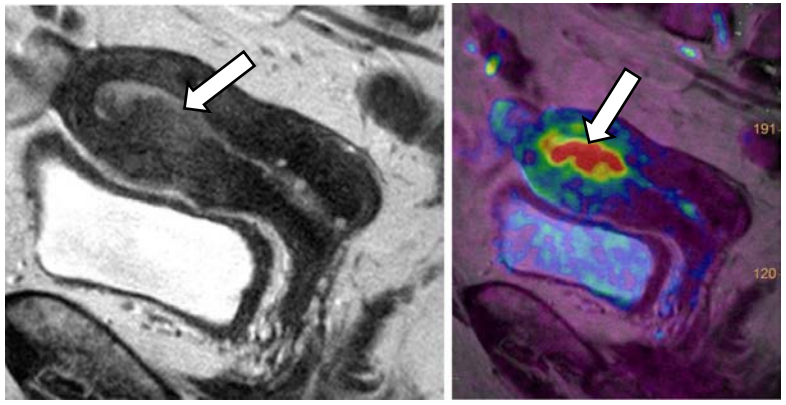
Endometrial Cancer: MRI

MRI is the preferred method for staging endometrial cancer, with a dedicated pelvic protocol enhancing local staging accuracy. It shows the tumor as hypo- to isointense on T1, less enhanced than the normal endometrium in post-gadolinium, and heterogeneous on T2. DWI sequences highlight restricted diffusion, aiding in assessing myometrial invasion

Endometrial cancers visualized by sagittal T2WI. a No cervical invasion; cervical stromal is preserved (white arrow). b Direct cervical invasion; cervical stroma is invaded (red arrow)

Reproduced from: Otero-García, M. et al(2019). Role of MRI in staging and follow-up of endometrial and cervical cancer: pitfalls and mimickers. Insights into Imaging, 10(1), 1–22. https://doi.org/10.1186/S13244-019-0696-8/FIGURES/25





FIGO IA endometrial tumor (arrows) with myometrial invasion of < 50% is isointense in T2WI images (a) and well-delineated in fused T2WIDWI images (b)

Reproduced from: Otero-García, M. et al(2019). Role of MRI in staging and follow-up of endometrial and cervical cancer: pitfalls and mimickers. Insights into Imaging, 10(1), 1–22. https://doi.org/10.1186/S13244-019-0696-8/FIGURES/25

Chapter Outline

Ovarian Cancer

Ovarian cancer is often called the "silent killer" because it can progress without symptoms until it reaches an advanced stage. Symptoms may include abdominal pain, bloating, menstrual irregularities and changes in bowel or urinary habits. Ovarian cancers are typically categorized into three main groups based on their cell type and origin. These groups are:

Epithelial Tumors: These are the most common ovarian cancers, arising from the epithelium or the outer surface of the ovary. Epithelial tumors include several subtypes such as serous, mucinous, endometrioid, and clear cell carcinomas.

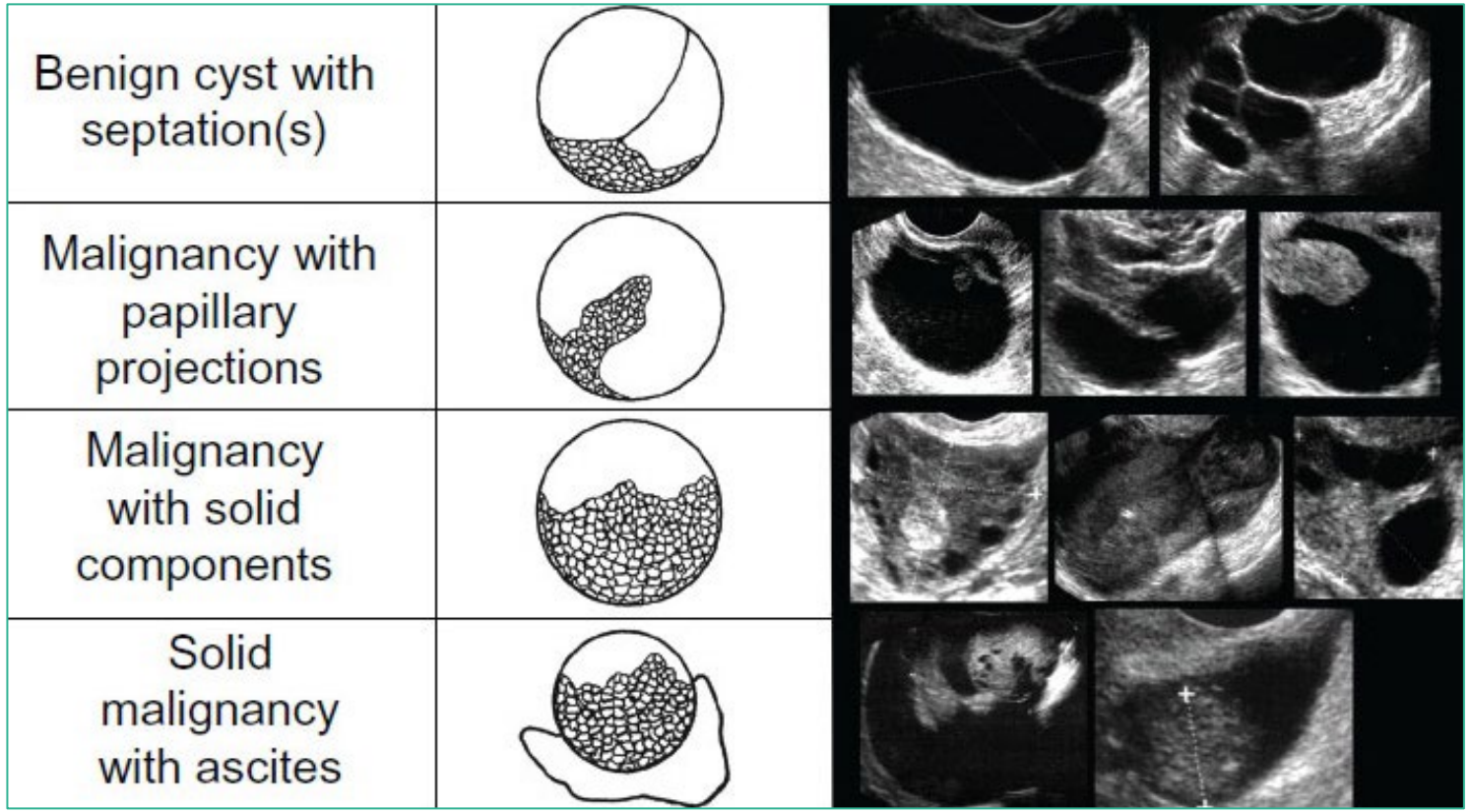
Germ Cell Tumors: These originate from the cells that produce the ova (eggs). Although they are much less common than epithelial tumors, germ cell tumors tend to occur in younger women. The subtypes include teratomas, dysgerminomas, and endodermal sinus tumors.

Stromal Tumors: These arise from connective tissue cells that hold the ovary together and produce the female hormones estrogen and progesterone. This type of cancer is often found in the early stages. Vaginal bleeding is one of the most common Examples of stromal tumors include granulosa cell tumors and Sertoli-Leydig cell tumors.

Chapter Outline

Ovarian Cancer: Ultrasound

Ovarian cancer may present as complex cystic masses with papillary projections or solid components. Color Doppler may reveal increased vascularity within the tumor.



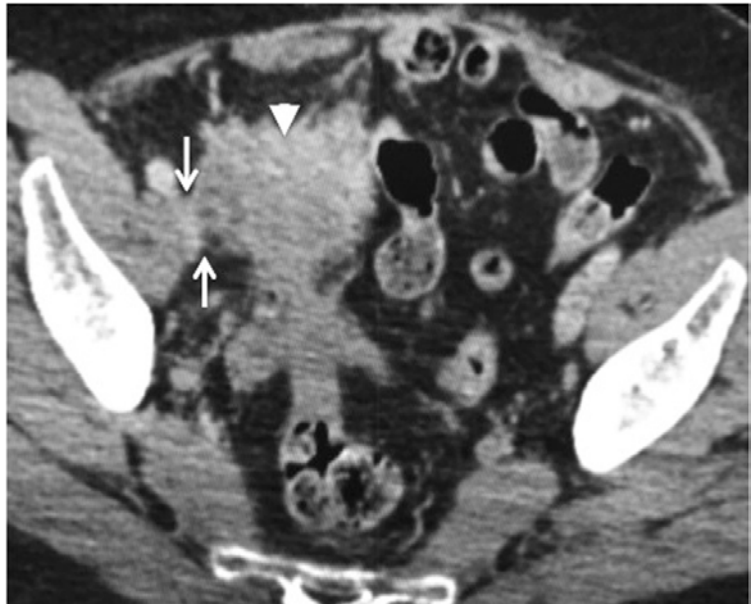
Sonographic images of benign and malignant ovarian morphology. increasing morphologic complexity is noted from Top to bottom

Reproduced from: van Nagell, J. R., Jr, & Hoff, J. T. (2013). Transvaginal ultrasonography in ovarian cancer screening: current perspectives. International journal of women's health, 6, 25–33. https://doi.org/10.2147/IJWH.S38347

Chapter Outline

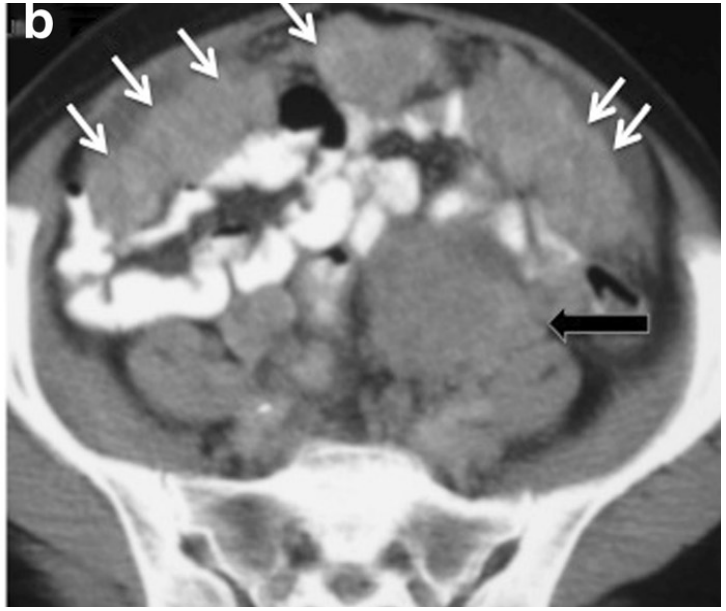
Ovarian Cancer: CT

Often shows ovarian enlargement with irregular cystic and solid areas. Ascites, omental caking, and peritoneal involvement may be present in advanced cases.



Right sided malignant ovarian mass (arrowhead). The mass extends to the right pelvic side wall and abuts the right external iliac vein (arrows). A distance of less than 3 mm from the pelvic side wall structures is highly suggestive of invasion

Reproduced from: Sahdev A. (2016). CT in ovarian cancer staging how to review and report with emphasis on abdominal and pelvic disease for surgical planning. Cancer imaging : the official publication of the International Cancer Imaging Society, 16(1), 19. https://doi.org/10.1186/s40644-016-0076-2



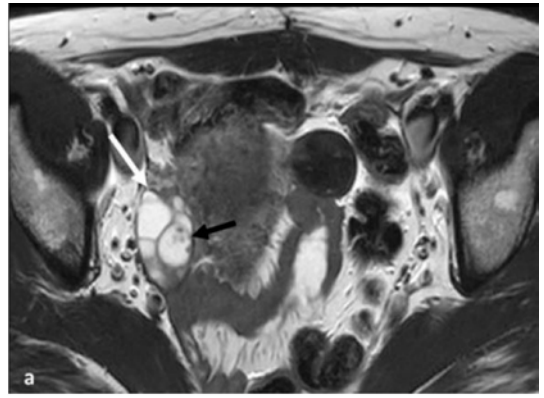
Undifferentiated adenocarcinoma of the ovary. The dashed arrows show extensive diffuse meso colic disease posterior to the transverse colon confluent with diffuse small bowel serosal disease. The disease results in small bowel obstruction. Solid arrows show a typical thick omental cake in the lower abdomen and a large peritoneal deposit (black arrow)

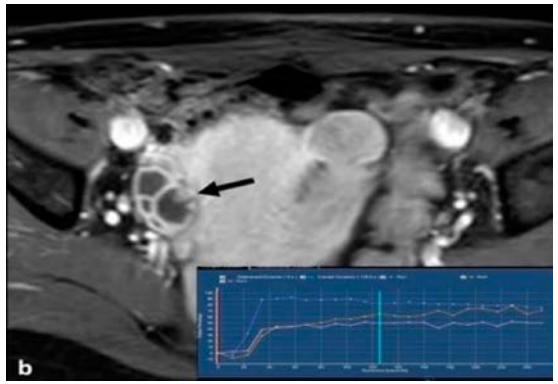
Reproduced from: Sahdev A. (2016). CT in ovarian cancer staging how to review and report with emphasis on abdominal and pelvic disease for surgical planning. Cancer imaging : the official publication of the International Cancer Imaging Society, 16(1), 19. https://doi.org/10.1186/s40644-016-0076-2

Chapter Outline

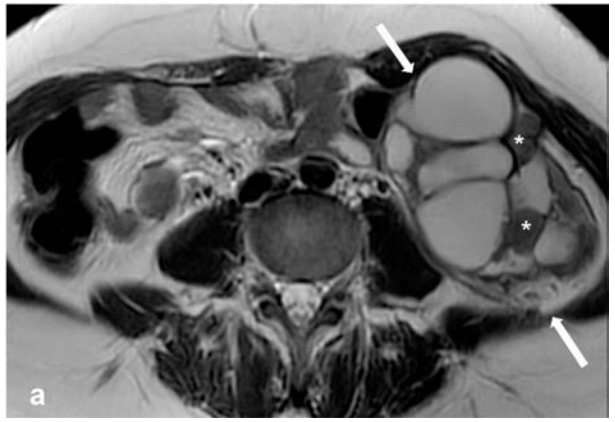
Ovarian Cancer: MRI

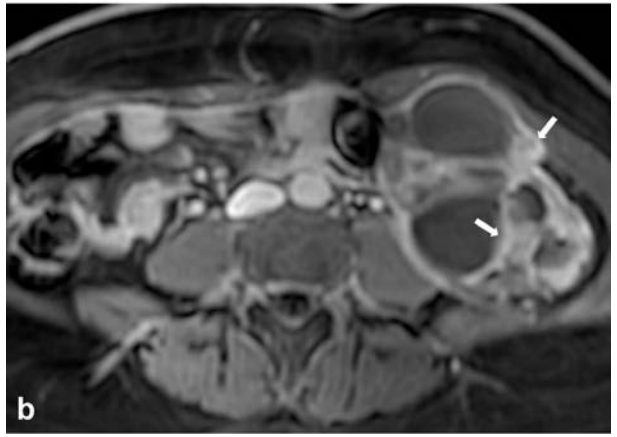
MRI findings suggestive of malignancy include the demonstration of solid masses, solid/cystic masses and the presence of papillary projections (vegetations) and thick septa in a cystic lesion Secondary features of malignancy are: peritoneal, mesenteric or omental involvement, pelvic side wall invasion and lymphadenopathy. Diffusion-weighted imaging (DWI) can aid in characterizing lesions.





Serous epithelial borderline ovarian tumor. Axial T2 weighted image (**a**) shows a multiloculated cystic lesion at the right ovary (white arrow). A small, papillary projection (black arrow) is present, with avid enhancement on the T1 weighted FS CE image ((**b**), black arrow). An intermediate-risk time intensity curve (TIC type 2) was detected on DCE image analysis (inset in b, blue line: myometrium, orange/pink lines: papillary projection.





Low grade serous cystadenocarcinoma. Axial T2 weighted image (a) shows a multiloculated, predominantly cystic mass at the left ovary (white arrows) with solid tissue (asterisks) showing avid enhancement on the T1 weighted FS CE image ((b), white arrows)

All images on this page are reproduced from:
Bourgioti, C., Konidari, M., & Moulopoulos, L. A. (2023). Manifestations of Ovarian Cancer in Relation to Other Pelvic Diseases by MRI. Cancers 2023, Vol. 15, Page 2106, 15(7), 2106. https://doi.org/10.3390/CANCERS15072106

Chapter Outline

Cervical Cancer

Cervical cancer is often associated with human papillomavirus (HPV) infection. It may present with abnormal vaginal bleeding, vaginal discharge, pelvic pain, or as an abnormal Pap smear result. The different histological types have distinct characteristics and clinical behaviors.

Two main types of cervical cancer are :

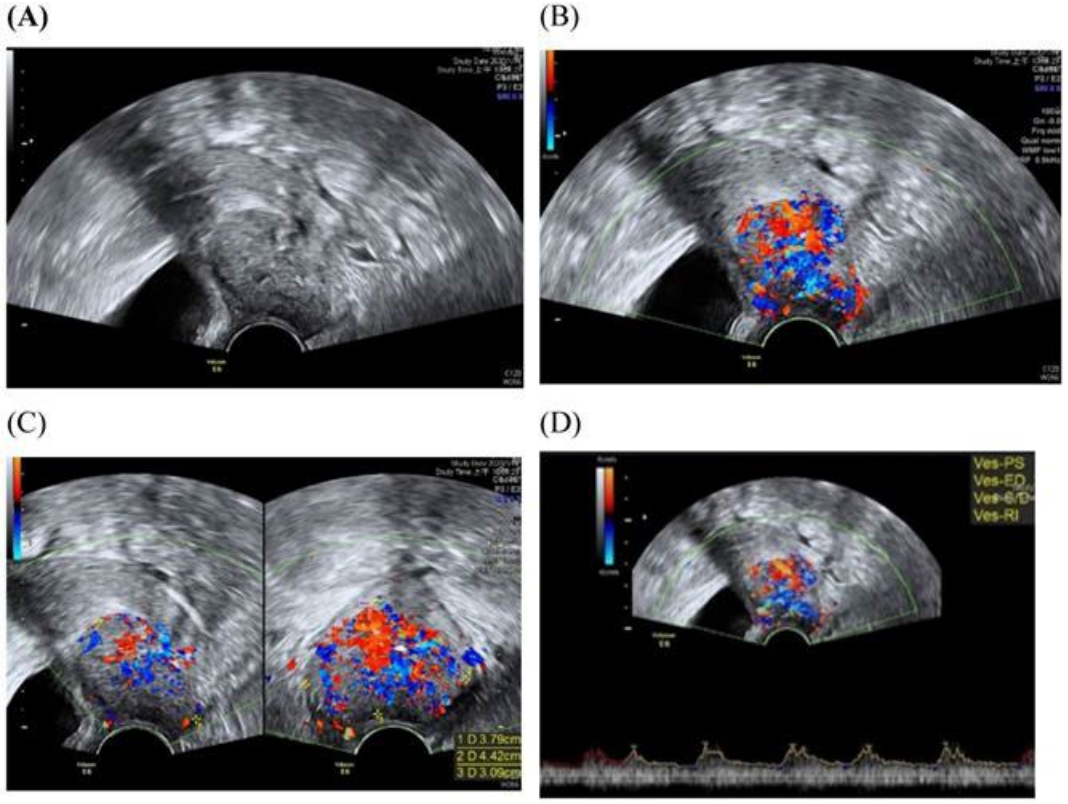
Squamous cell carcinoma:
This is the most common type and arises from the squamous epithelial cells of the cervix.

Adenocarcinoma:
Adenocarcinoma of the cervix arises from glandular cells and tends to be diagnosed at a more advanced stage

Chapter Outline

Cervical Cancer: Ultrasound

On ultrasound, cervical cancer presents as a hypoechoic and heterogeneous mass in the cervix, often with increased blood flow on color Doppler imaging. Ultrasound serves as an adjunct to clinical staging, providing details on the tumor's size, its spread to the parametrium and vagina, invasion into nearby organs, and the presence of hydronephrosis, which can indicate a more advanced stage.



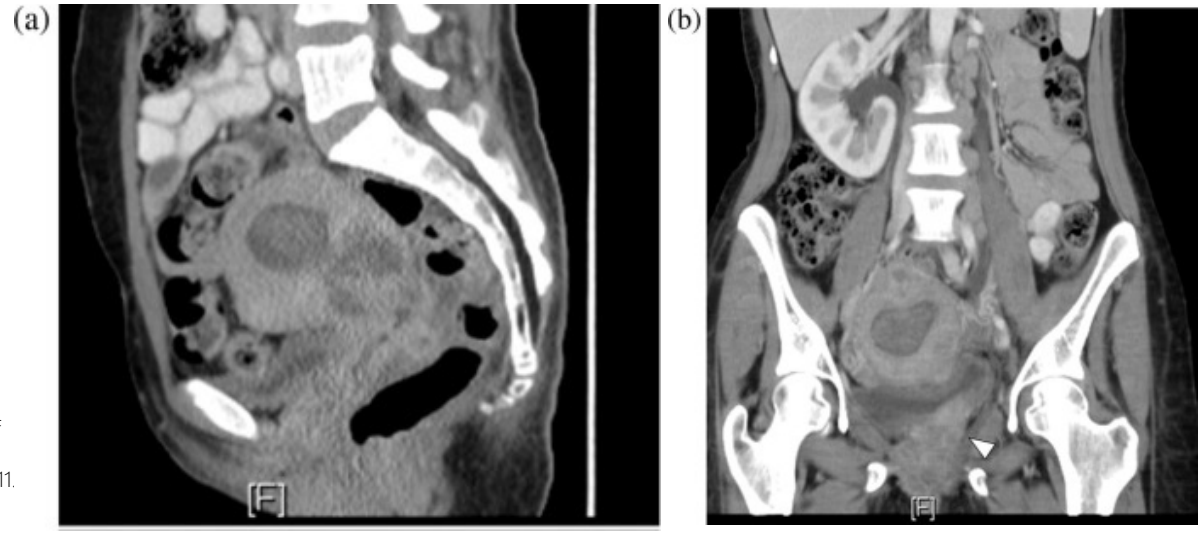
Transvaginal ultrasound image gray scale and color Doppler shows a longitudinal section of the uterus with cervical cancer (A) Gray scale shows cervical mass (B) color Doppler shows abundant blood flow in cervical mass (C) color Doppler (D) color Doppler Blood flow

Reproduced from: Hsiao, Y. H., Yang, S. F., Chen, Y. H., Chen, T. H., Tsai, H. D., Chou, M. C., & Chou, P. H. (2021). Updated applications of Ultrasound in Uterine Cervical Cancer. Journal of Cancer, 12(8), 2181–2189. https://doi.org/10.7150/jca.49479

Chapter Outline

Cervical Cancer: CT

In cervical cancer, CT is less effective for evaluating the primary tumor but is valuable for assessing advanced disease. Its primary role lies in detecting lymphadenopathy and defining the extent of advanced disease, including distant metastases. CT is also instrumental in planning radiation therapy and guiding percutaneous biopsies. On CT scans, the primary cervical tumor may appear as hypo-enhancing or iso-enhancing relative to the normal cervical stroma.



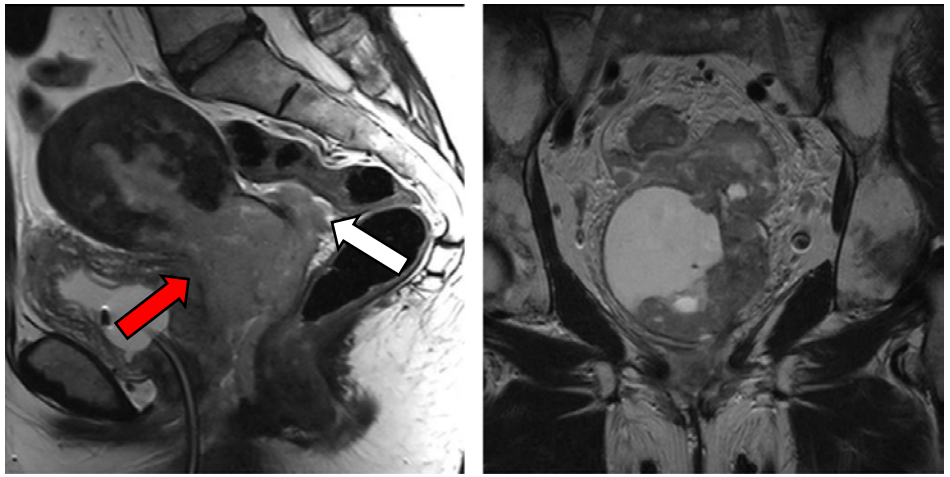
41-year-old patient with a history of premenopausal bleeding of 6-month duration. Sagittal (A) and coronal images (B). (A) Heterogenous hypoattenuating cervical mass is seen extending to fundus. (B) Together with infiltration of the bladder from its inferior aspect causing enhancement of bladder wall (arrow).

Reproduced from : Helal, M. H., Mostafa, A. M., Mansour, S. M., Noaman, M. K., & Beshir, M. M. R. (2017). Loco-regional staging of cervical carcinoma: Is there a place for Multidetector CT? The Egyptian Journal of Radiology and Nuclear Medicine, 48(1), 307–311. https://doi.org/10.1016/J.EJRNM.2016.11.006

Chapter Outline

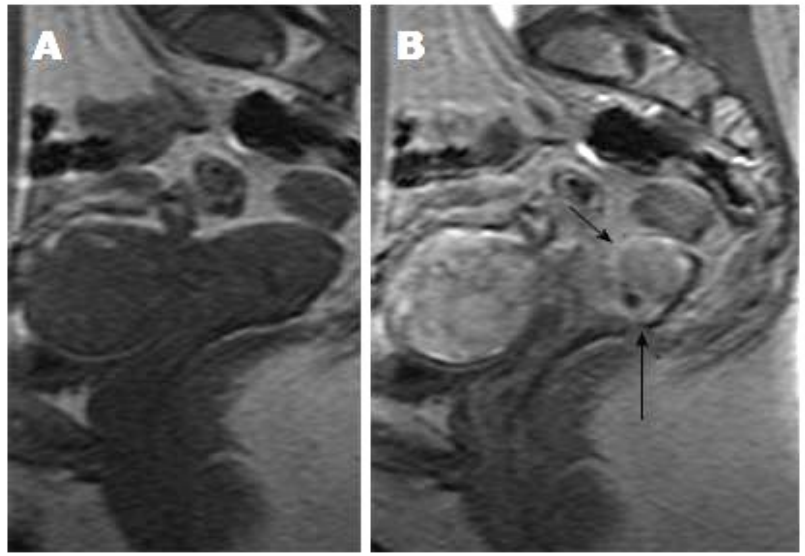
Cervical Cancer: MRI

The tumor typically appears isointense to pelvic muscles on T1-weighted images, but on T2-weighted images, it is hyperintense against the low signal of the normal cervical stroma. This high signal on T2 is consistent across histological subtypes. While contrast-enhanced MRI is not routinely necessary, it can be particularly useful for identifying smaller tumors. The tumor usually appears as a higher signal when compared to the lower signal of the cervical stroma on T1-weighted images.



FIGO Stage IVA cervical cancer with bladder invasion. Visualization by sagittal T2WI (a) and coronal T2WI (b) reveals cervical cancer invading the bladder mucosa (red arrow) and rectouterine space (white arrow)

Reproduced from: Otero-García, M et al. (2019). Role of MRI in staging and follow-up of endometrial and cervical cancer: pitfalls and mimickers. Insights into Imaging, 10(1), 1–22. https://doi.org/10.1186/S13244-019-0696-8/FIGURES/25



Dynamic contrast enhanced images, cervical cancer. Sagittal pre- (A) and early arterial (30 s) post contrast (B) images. Cervical tumor borders are clearly delineated on the enhanced image (arrows in B). Note early arterial enhancement of cervical tumor in (B) synchronous with that of myometrium.

Reproduced from: Bourgioti, C., Chatoupis, K., & Moulopoulos, L. A. (2016). Current imaging strategies for the evaluation of uterine cervical cancer. World journal of radiology, 8(4), 342–354. https://doi.org/10.4329/wjr.v8.i4.342

Chapter Outline

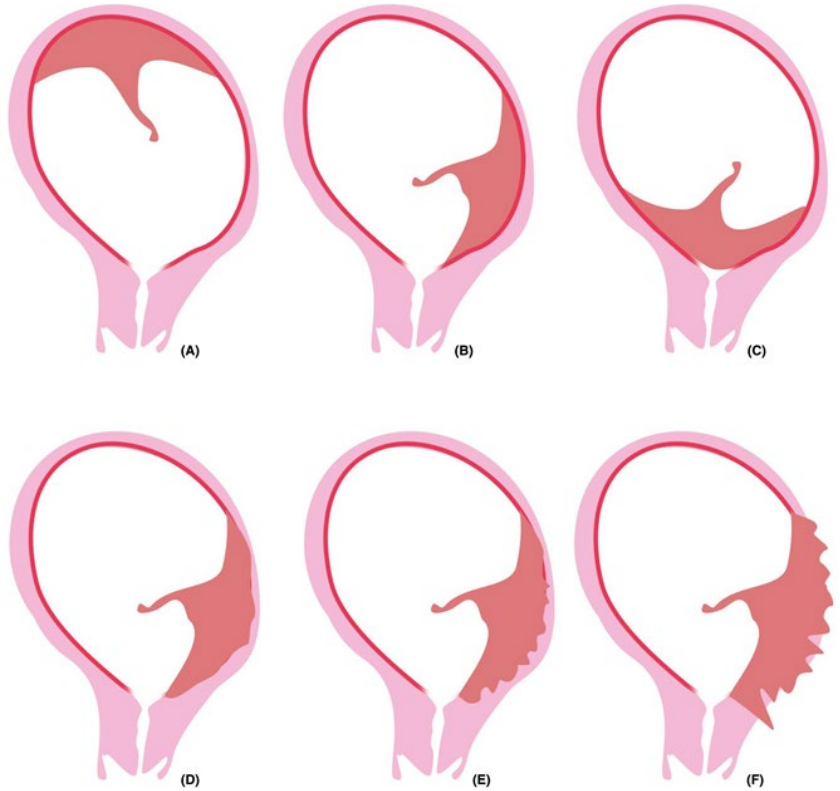
Common Pregnancy and Delivery-Related Disorders
Placental Abnormalities

Placental abnormalities can occur during pregnancy and may lead to complications.

Types:

Placenta Previa: In this condition, the placenta partially or completely covers the cervix. It can result in painless vaginal bleeding during the second or third trimester.

Placenta Accreta, Increta and Percreta : In placenta accreta, the placenta attaches firmly to the uterine wall but does not penetrate the muscle. Placenta increta occurs when the placenta invades into the myometrium, and in placenta percreta, the most severe form, the placenta perforates through the myometrium and may extend to nearby organs.



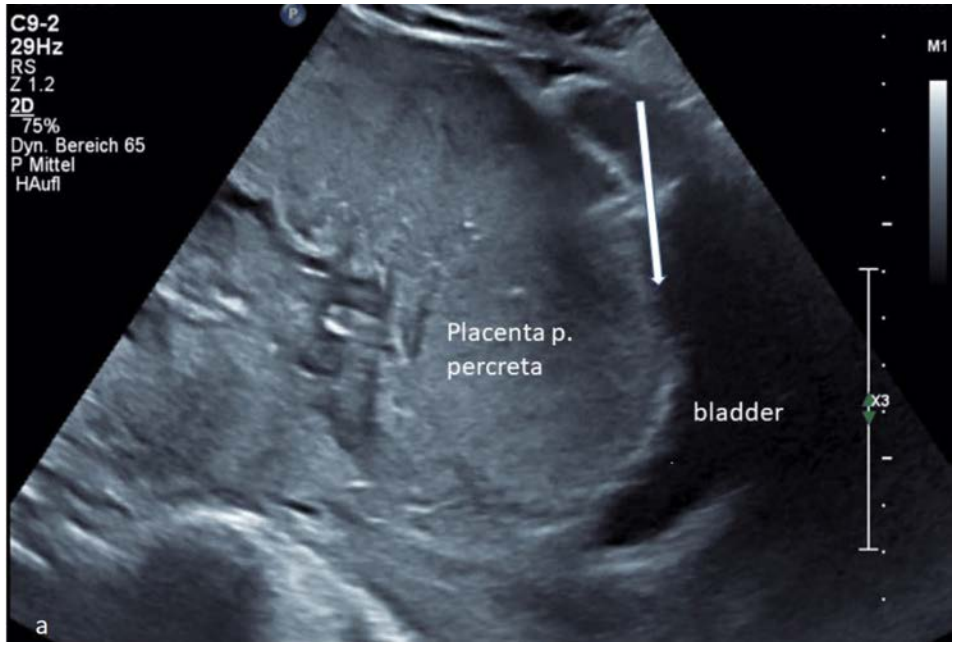
Placental abnormalities in location and anatomy: (A) normal localization, (B) low-lying placenta, (C) placenta previa, (D) placenta accreta, (E) placenta increta, (F) placenta percreta

Reproduced from: Jansen, C. H. J. R et al .(2020). Development of placental abnormalities in location and anatomy. Acta obstetricia et gynecologica Scandinavica, 99(8), 983–993. https://doi.org/10.1111/aogs.13834

Chapter Outline

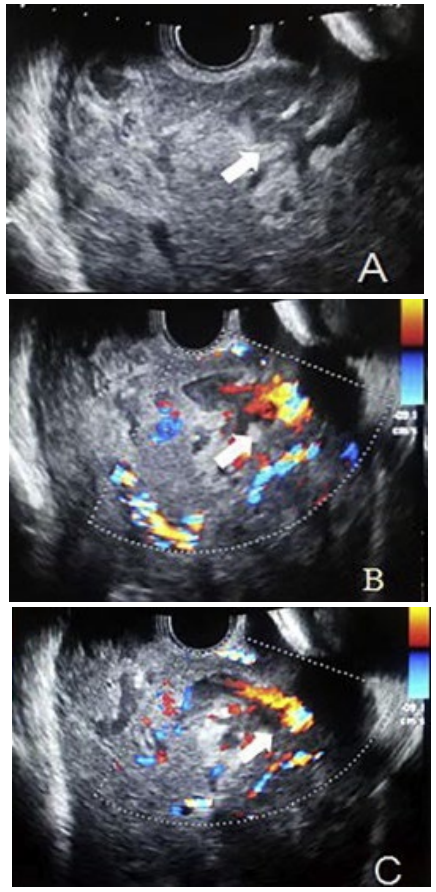
Placental Abnormalities: Ultrasound

Ultrasound imaging can detect placenta previa and may show placental lacunae, which appear as irregular vascular channels with turbulent flow, creating a "Swiss cheese" appearance. It may also show abnormal Doppler flow, loss of the retroplacental clear space, and notably thin myometrium, sometimes less than 1 mm.



Transvaginal ultrasound presentation of a placenta previa totalis et percreta at 34 weeks gestation with a small tissue layer (arrow) towards the urinary bladder

Reproduced from: Bachmann, C., Abele, H., & Hoopmann, M. (2023). Placenta Previa et Percreta: A Potentially Life-Threatening Condition. Diagnostics (Basel, Switzerland), 13(3), 539. https://doi.org/10.3390/diagnostics13030539



Placenta accreta.
(A) Gray scale transvaginal: Arrow shows placental lacunae. (B) Color Doppler of the same region shows turbulent flow of venous, arterial or mixed blood. (C) Color Doppler of the same region shows Tornado sign (arrow).

Reproduced from: Shawky, M., AbouBieh, E., & Masood, A. (2016). Gray scale and Doppler ultrasound in placenta accreta: Optimization of ultrasound signs. The Egyptian Journal of Radiology and Nuclear Medicine, 47(3), 1111–1115. https://doi.org/10.1016/J.EJRNM.2016.04.010

Chapter Outline

Placental Abnormalities: MRI

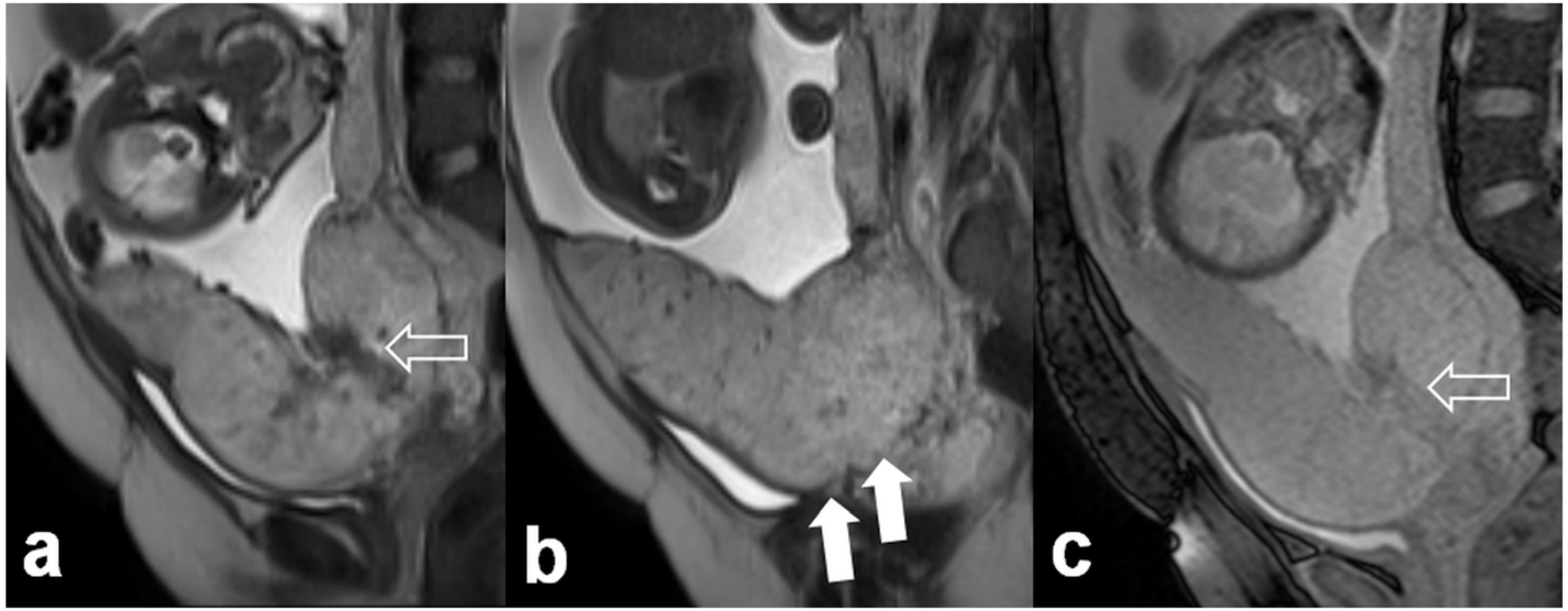
Using standardized SAR/ESUR protocols, MRI without contrast is performed with T2-weighted and fat-suppressed T1-weighted sequences to detect signs of abnormal placental invasion. Key features include a bulging placenta, uterine contour changes, placental tissue within the bladder area, heterogeneous myometrial vessels, and thinning of the myometrium. Optional sequences like DWI/ADC can provide additional detail on placental vascularity.

Representative findings of myometrial interruption and focal uterine bulging in patients with placenta accreta spectrum. (A) Sagittal T2-weighted images showing focal myometrial interruption (empty oval) in the anterior placenta of a patient with placenta increta. (B) Sagittal T2-weighted images showing focal myometrial thinning (empty oval) in the posterior placenta of a patient with placenta accreta. (C) Sagittal T2-weighted images showing focal uterine bulging (broken line) in the anterior placenta of a patient with placenta percreta. (D) Sagittal T2-weighted images showing focal uterine bulging (broken line) in the posterior placenta of a patient with placenta accreta

Reproduced from: Bachmann, C., Abele, H., & Hoopmann, M. (2023). Placenta Previa et Percreta: A Potentially Life-Threatening Condition. Diagnostics (Basel, Switzerland), 13(3), 539. https://doi.org/10.3390/diagnostics13030539

Chapter Outline

Placental Abnormalities: MRI



23-year-old woman (gravida −2) with history of previous Caesarean section. The sagittal T2 HASTE (a, b) and SSFP (c) MR images show placenta previa with dark bands (open arrows) and loss of uteroplacental interface (arrows). Since placenta accreta was present during elective Caesarean section, uterine artery embolization was performed, and she was placed on follow-up

Reproduced from: Mahalingam, H. V., Rangasami, R., Premkumar, J., & Chandrasekar, A. (2021). Placenta accreta scoring system (PASS)—assessment of a simplified clinico-radiological scoring system for antenatal diagnosis of placenta accreta. Egyptian Journal of Radiology and Nuclear Medicine, 52(1), 1–6. https://doi.org/10.1186/S43055-021-00427-Y/TABLES/2

Chapter Outline

Common Pregnancy and Delivery-Related Disorders
Ectopic Pregnancy

Ectopic pregnancy occurs when a fertilized egg implants outside the uterus, most commonly in the fallopian tube.

Types:

Tubal Pregnancy: The most common type, where the embryo implants in the fallopian tubes. It can further be classified based on the specific site within the tube (ampullary, isthmic, fimbrial).

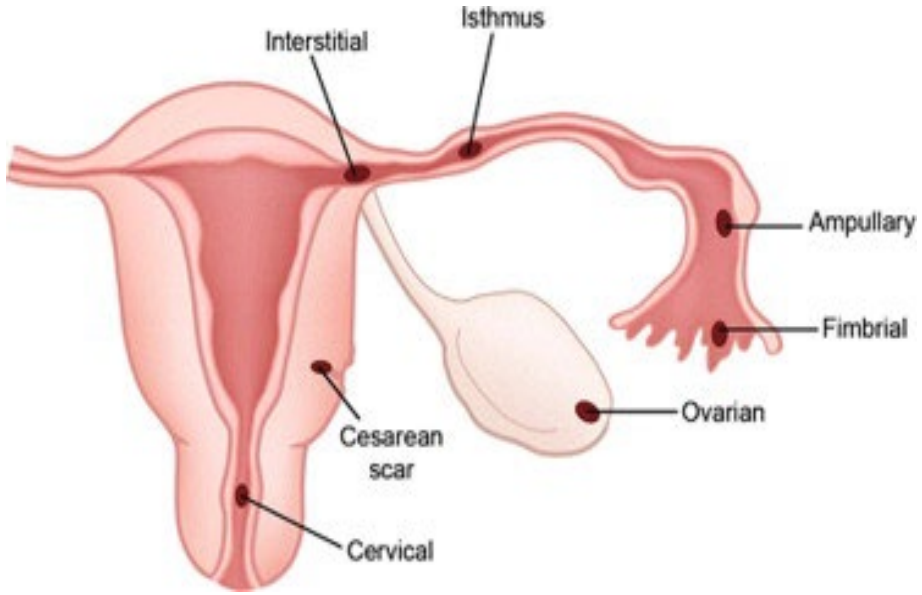
Ovarian Pregnancy: The embryo implants on the surface of the ovary.

Cervical Pregnancy: Implantation occurs within the cervical canal, which is particularly dangerous due to the risk of heavy bleeding.

Interstitial Pregnancy: The embryo implants in the interstitial part of the tube, which is the portion that passes through the uterine musculature.

Abdominal Pregnancy: A rare form where the embryo implants in the abdominal cavity, outside the reproductive organs.

Caesarean Scar Pregnancy: Implantation occurs within the scar of a previous caesarean section.



Usual and unusual sites of ectopic pregnancy

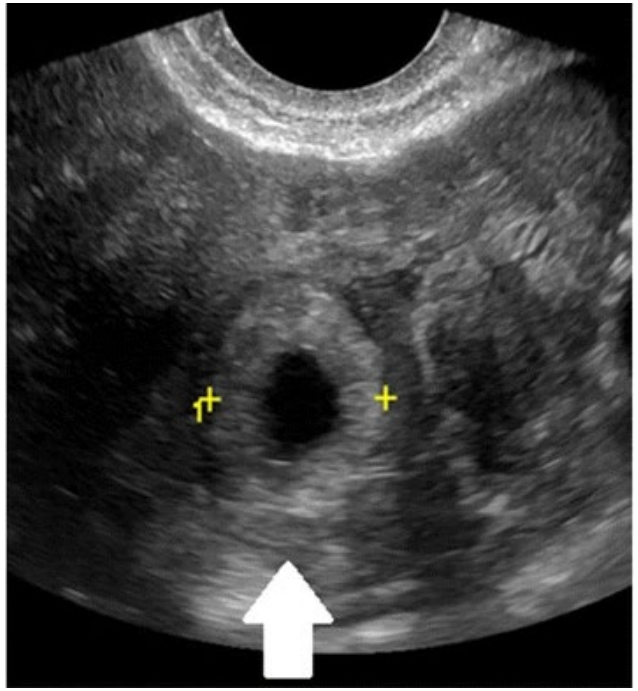
Reproduced from : Badr, S., Ghareep, A.-N., Abdulla, L. M., & Hassanein, R. (2013). Ectopic pregnancy in uncommon implantation sites. The Egyptian Journal of Radiology and Nuclear Medicine, 44(1), 121–130. https://doi:10.1016/j.ejrnm.2012.10.006

Chapter Outline

Ectopic Pregnancy: Ultrasound

Ultrasound is the primary imaging modality for diagnosing ectopic pregnancy. US features of ectopic pregnancy include :

- Tubal Ring Sign: A hyperechoic ring surrounding an extrauterine gestational sac, often seen in tubal pregnancies.
- Free Fluid: Especially in the pouch of Douglas, suggesting potential rupture and hemoperitoneum.
- Adnexal Mass: Presence of an adnexal mass separate from the ovary.
- Absence of Intrauterine Pregnancy: Especially in the presence of a positive pregnancy test



Tubal ectopic pregnancy by transvaginal ultrasound. The arrow indicates the ectopic gestation with a surrounding hyperechoic ring, called the 'bagel' or 'tubal' sign

Reproduced from: Panelli, D. M., Phillips, C. H., & Brady, P. C. (2015). Incidence, diagnosis and management of tubal and nontubal ectopic pregnancies: a review. Fertility research and practice, 1, 15. https://doi.org/10.1186/s40738-015-0008-z

Unilateral twin ectopic pregnancy. Transvaginal ultrasound scan of the right adnexa, demonstrating two distinct gestational sacs, situated within the right fallopian tube.

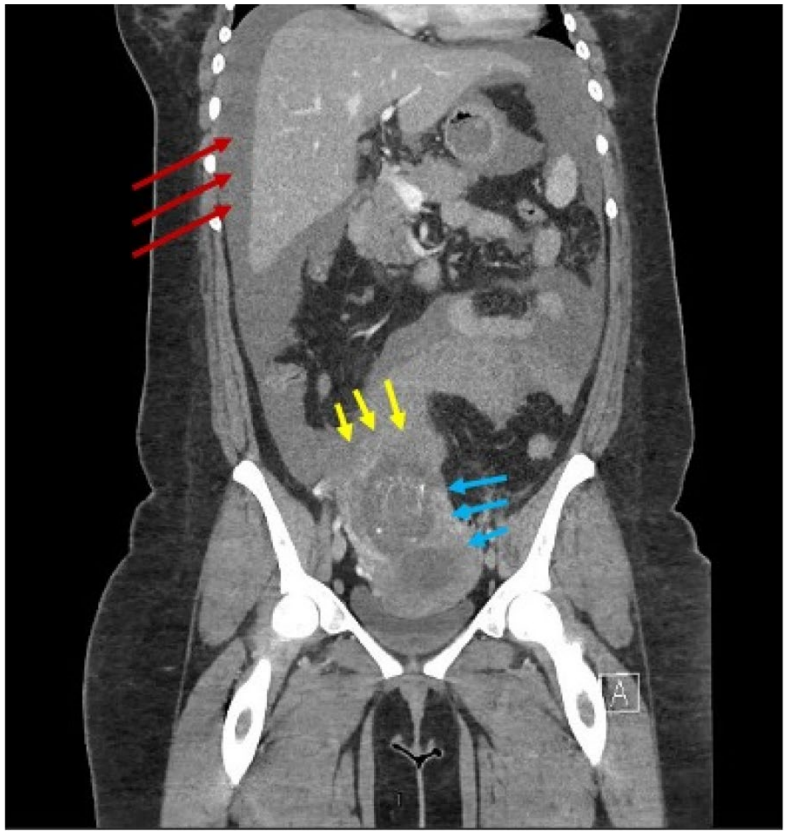
Reproduced from: Martin, A., Balachandar, K., & Bland, P. (2021). Management of a spontaneously conceived live unilateral twin ectopic pregnancy in Australia: A case report. Case Reports in Women's Health, 30, e00300. https://doi.org/10.1016/J.CRWH.2021.E00300

Chapter Outline

Ectopic Pregnancy: CT

CT is not routinely used for diagnosing ectopic pregnancy due to radiation exposure. However, it may be used in emergency settings to identify rupture and associated hemoperitoneum.

CT may reveal pelvic masses, free fluid, and blood in the abdomen, indicative of a ruptured ectopic pregnancy.



CT scan of the abdomen and pelvis in the coronal plane. The scan revealed large volume hemoperitoneum (red arrows), location of interstitial ectopic pregnancy (blue arrows), an empty uterine cavity (blue arrows), and the area of suspected rupture (yellow arrows)

Reproduced from: Ahlschlager, L. M., Mysona, D., & Beckham, A. J. (2021). The elusive diagnosis and emergent management of a late-presenting ruptured interstitial pregnancy: a case report. BMC Pregnancy and Childbirth, 21(1), 1–5. https://doi.org/10.1186/S12884-021-04026-7/FIGURES/5

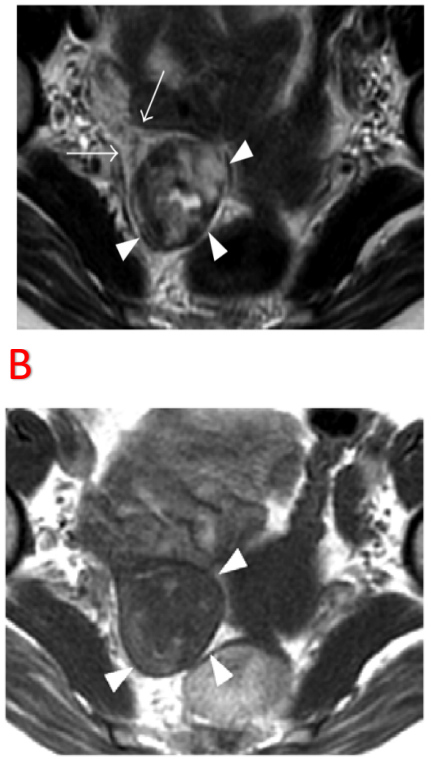
Chapter Outline

Ectopic Pregnancy: MRI

MRI is typically used when ultrasound findings are inconclusive, especially in complex cases.

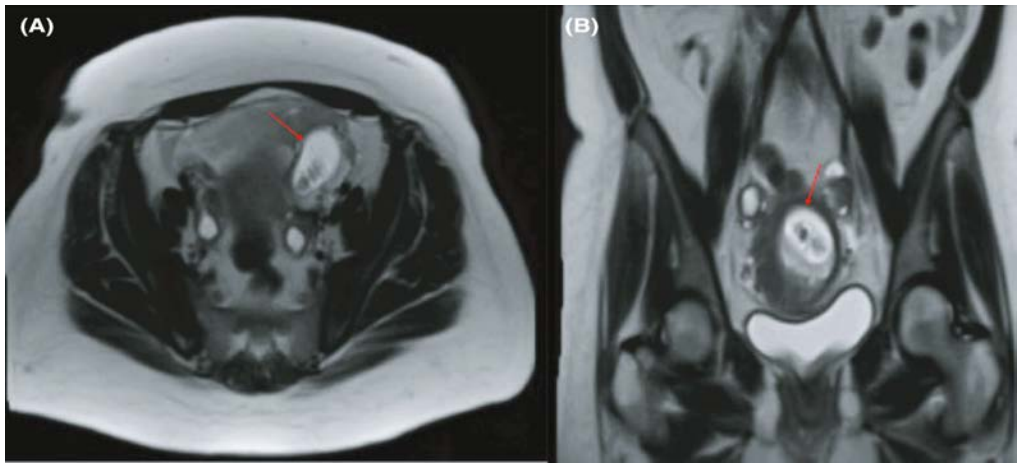
MRI can provide detailed information about the location and extent of the ectopic pregnancy.

Ectopic gestational sacs may appear as a mass in the adnexal region, with or without a yolk sac or embryo. MRI can also detect hemorrhage and distinguish ectopic pregnancy from other pelvic pathologies.



Ovarian pregnancy, rare form of ectopic pregnancy
(A) Axial T2-weighted MR image shows a GS structure of heterogeneous high intensity (arrowhead), containing punctate foci of distinct low intensity. The GS is incarcerated to the right ovary, forming a "beak sign" (arrows). (B) Axial T1-weighted MR image showed GS structure (arrowhead) containing punctate foci of high intensity.

Reproduced from: Io, S., Hasegawa, M., & Koyama, T. (2015). A Case of Ovarian Pregnancy Diagnosed by MRI. Case Reports in Obstetrics and Gynecology, 2015, 1–3. https://doi.org/10.1155/2015/143031



T2-weighted axial and coronal images showing left tubal ectopic pregnancy seen as a sac-like lesion with thick wall measures 56 x 35 x 46 mm contains fetus with crown-rump length 27 mm and intrauterine pregnancy with same crown-rump length.

Reproduced from: Abdelmonem, A. H., Sayed, G., Abugazia, A. E., Kohla, S., & Youssef, R. (2021). Heterotopic pregnancy after a spontaneous conception a case report with a review of clinical, laboratory and imaging findings. Clinical Case Reports, 9(8), e04649. https://doi.org/10.1002/CCR3.4649

Chapter Outline

Take-Home Messages (1)

Ultrasound (US)
- Primary tool for initial assessment, especially in pregnancy.
- Effective in diagnosing ectopic pregnancies, placental disorders, and ovarian cysts.
- Offers real-time imaging, crucial for emergency conditions like ovarian torsion.

MRI:
- Ideal for complex gynecological cancers (endometrial, ovarian, cervical) due to superior soft tissue contrast.
- Essential in assessing placenta accreta spectrum disorders, following SAR/ESUR guidelines.
- Useful in differentiating benign from malignant pelvic masses.

Computed Tomography (CT):
- Employed for evaluating advanced stages of gynecological cancers and detecting metastasis.
- Useful in emergency settings for conditions like ruptured ectopic pregnancy.
- Limited use in pregnancy due to radiation exposure

Chapter Outline

Take-Home Messages (2)

In this presentation on female pelvic imaging, we've highlighted the importance of using the appropriate imaging modality based on the patient's clinical scenario.

Key points include:

Common Conditions: Master the imaging characteristics of endometrial, ovarian, and cervical cancers, and ectopic pregnancy. Customize imaging strategies for each clinical situation to ensure precise diagnosis and effective treatment.

Routine Pregnancy Screening: Essential for women of childbearing age before any radiologic procedure involving ionizing radiation.

Risk-Benefit Analysis: Assess the necessity of the imaging procedure, weighing potential risks to the fetus.

Ultrasound and MRI Preference: Recommended due to their safety in pregnancy.

Limited Use of CT Scans: Utilized only when necessary, with dose optimization.

Radiation Dose Management: Aim to limit the radiation dose as much as possible.

Patient Education: Important to inform patients about the risks and benefits of radiologic procedures during pregnancy.

Collaborative Decision-Making: Multidisciplinary approach for optimal patient care. Thorough Documentation: Documenting the rationale for the imaging modality choice is crucial.

For detailed guidelines and best practices, refer to the ACR-SPR practice parameters.

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Chapter Outline

Test Your Knowledge

1 - What is the primary imaging modality for diagnosing ectopic pregnancy?

- MRI
- CT Scan
- Ultrasound
- X-ray

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Test Your Knowledge

2- What is the primary role of CT in the evaluation of cervical cancer?

- Evaluating the primary tumor
- Detecting lymphadenopathy and defining the extent of advanced disease
- Diagnosing early-stage disease
- Guiding surgical procedures

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- CT and X-ray
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- Nuclear Medicine Scans Evaluating the primary tumor

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4- For what purpose is CT used in emergency settings related to pregnancy?

- Routine check-ups
- Evaluating placental position
- Identifying rupture and associated hemoperitoneum in ectopic pregnancy
- Assessing fetal development

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- Fetal heart rate
- Amniotic fluid level
- Placenta previa and placental lacunae
- Gender of the fetus

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- Ovarian cyst
- Extrauterine gestational sac, often seen in tubal pregnancies
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- A complex mass with both cystic and solid components
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- Hypoechoic fluid-filled structure
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Test Your Knowledge

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