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REVIEW ARTICLE

Pelvic Ultrasound Simulation Training Models and Case Scenarios

[1]Jorge Sarmiento, [2]Kevan Stewart, [3]Jorge Aguila, [4]Arya Bagherpour, [5]Sanja Kupesic Plavsic

ABSTRACT

Pelvic ultrasound simulation training using high-fidelity mannequins can provide a safe and controlled learning environment to foster the ultrasound education of medical students, residents and faculty. The instruction can be tailored to the specific needs of the learners. Topics for instruction range from teaching basic anatomy and ultrasound scanning techniques to common and advanced obstetrics and gynecology disease presentations and pathological processes. Simulation can closely approximate patient encounters using case based scenarios which will aid in developing knowledge and skills that can be transferred to the clinical environment. The goal of simulation is to help the learners to become more confident and competent to care for their patients.

Keywords: Pelvic ultrasound, Ultrasound simulator, Ultrasound simulation, Mannequin, Training, Case scenarios.

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INTRODUCTION

Pelvic ultrasound simulation training using high-fidelity mannequins can provide an environment to foster learning in the instruction of medical students, residents and faculty. Teaching modules and instruction can be tailored to the specific needs of the audience. For medical students and first year residents the simulation and training can initially be focused on developing basic ultrasound skills and learning anatomy. For more senior residents or faculty, the training can focus on promoting increased understanding of pathology, working as a team and communicating information effectively.

Part of our approach to teaching is helping learners develop in their minds what they expect to see on ultrasound based on the clinical scenario that was provided to them before they start scanning. When learners understand the potential pathology and anticipate pelvic ultrasound findings before they scan, it changes the outlook of diagnostic procedure. Instead of just scanning and seeing what they find, they transform their outlook to evaluating what they expect to see and identify where and why there is a deviation from what is expected. The idea is to stimulate more thoughtful discussion and maximize the learning experience. The use of simulation with mannequins enables discussion to occur at anytime during the learning process. The discussions that occur in the middle of a scanning session using a mannequin are without limits, while at the same time many of the discussions are considered inappropriate if actual patients are present. Mannequins enable learners to acquire skills in a controlled and safe environment where they can feel free to ask questions openly, get technical insights, make mistakes and develop their skills. High-fidelity mannequins can closely simulate actual patient encounters, so learners are able to gain experience that is directly transferrable to their clinical practice.

The use of high-fidelity mannequins in pelvic ultrasound simulation enables learners to gain experience in scanning specific pathological processes that they might not otherwise get the experience to scan unless they scanned thousands of patients. Some diseases are not as common and through simulation the learner can see how the disease presents, perform a full assessment, document the ultrasound findings and develop a treatment plan. Cases and scenarios for medical students may include common obstetrics and gynecology pathologies. More complex case scenarios and questions may be used to challenge more senior residents or faculty based on their individual knowledge and level of training. Mannequins may be used for education and developing technical skills, as well as for assessment. The goal of simulation is to increase the learners' knowledge and skills and subsequently increase their confidence and competence in the clinical environment, so they will be able to better care for their patients.

Here, we present nine case studies used for education of radiology residents at our institution. One-on-one feedback is provided to the learners after each simulation station.

[1]Assistant Professor, [2-4]Radiology Resident, [5]Assistant Dean

[1-4]Department of Radiology, Paul L Foster School of Medicine Texas Tech University Health Sciences Center at El Paso Texas, USA

[5]Department of Obstetrics and Gynecology, Paul L Foster School of Medicine, Texas Tech University Health Sciences Center at El Paso, Texas, USA

Corresponding Author: Jorge Sarmiento, Assistant Professor Department of Radiology, Paul L Foster School of Medicine, Texas Tech University Health Sciences Center, 4800 Alameda Ave, El Paso TX 79905, USA, Phone: (915) 5456845, e-mail: jorge.sarmiento@ttuhsc.edu

CASE REPORTS

Case 1

A 36-year-old female with no significant past medical history complains of intermittent mild pelvic pain. Pelvic ultrasound was performed and results are displayed in Figures 1 to 4. Identify all of the visualized anatomic structures.

Discussion

The learners should identify the uterine anatomical structures: fundus, uterine body, cervix and isthmus, followed by uterine layers (parametrium, myometrium and endometrium). At the end of case discussion, the learners should be able to identify the uterine position.

In the same image the learners should be able to identify the following uterine layers:

- *Parametrium* (P): Outer serous layer; part of the visceral peritoneum. Appears as a hyperechoic uterine outline.
- *Myometrium* (M): Middle muscular layer that forms the main bulk of uterus. Usually homogeneous, outlined by arcuate arteries.
- *Endometrium* (E): Internal mucous layer. The thickness and echogenicity are variable depending on the phase of the menstrual cycle or age. The endometrium is subdivided into two layers:
  – *Stratum functionale* (inner hypoechoic layer that becomes hyperechoic in the secretory phase): the thickness varies depending on cyclical changes.
  – *Stratum basale* (outer layer): thin and hyperechoic.

At the same time, the instructor discusses different types of uterine position:

- *Anteversion*: Uterine body bends forward (most common).
- *Retroversion*: Uterine body bends backward.
- *Anteflexed*: Fundus points anterior in relation to the cervix.
- *Retroflexed*: Fundus points posterior in relation to the cervix.

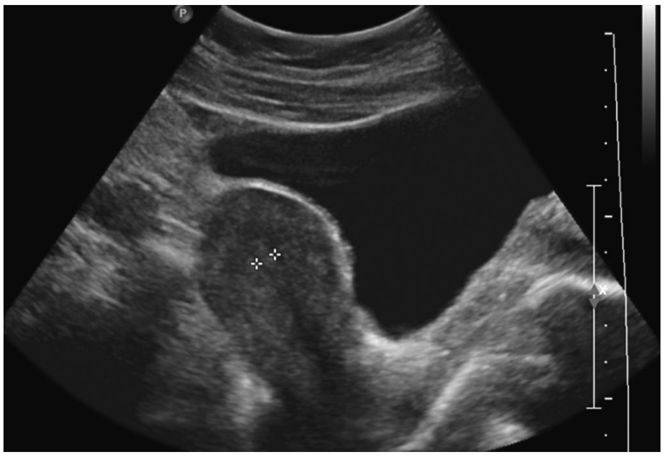


Fig. 1: Transabdominal ultrasound of the uterus

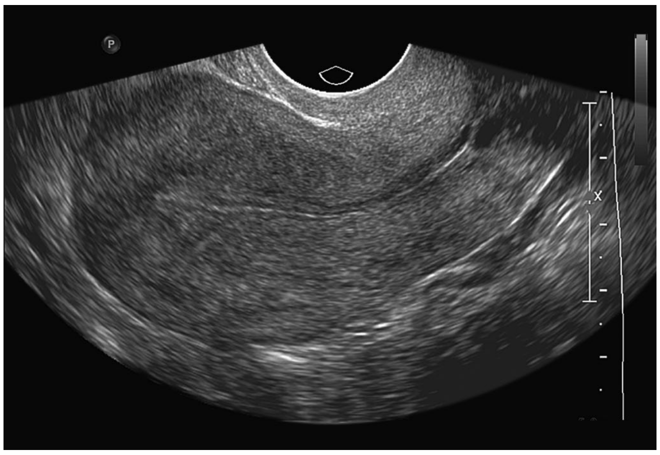


Fig. 2: Transvaginal ultrasound of the uterus

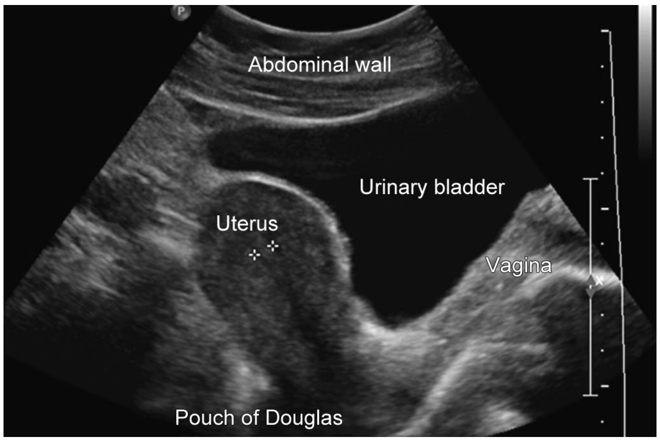


Fig. 3: Transabdominal ultrasound of the uterus. Note the urinary bladder, uterus, abdominal wall muscles and Pouch of Douglas

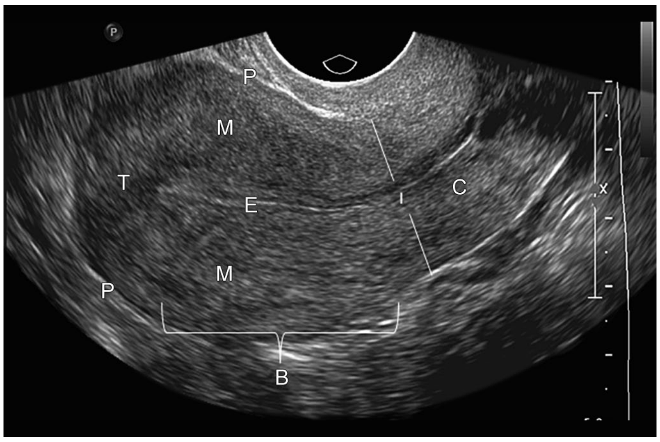


Fig. 4: Transvaginal ultrasound of the uterus. Note the uterine fundus (F), uterine body—upper 2/3 of the uterus (B), isthmus—junction between the body of the uterus and cervix (I) and cervix (C) lower 1/3 of the uterus

Case 2

A 32-year-old female who returns to ultrasound clinic for follow-up of a small right ovarian cystic structure. Identify the anatomical structures presented in Figures 5 to 8.

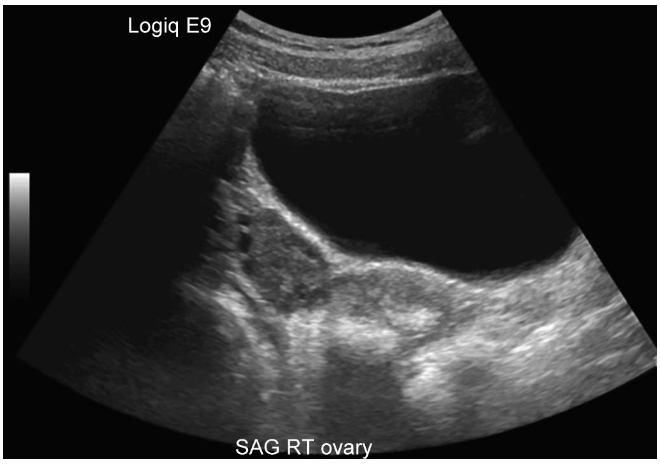


Fig. 5: Transabdominal ultrasound of the ovary

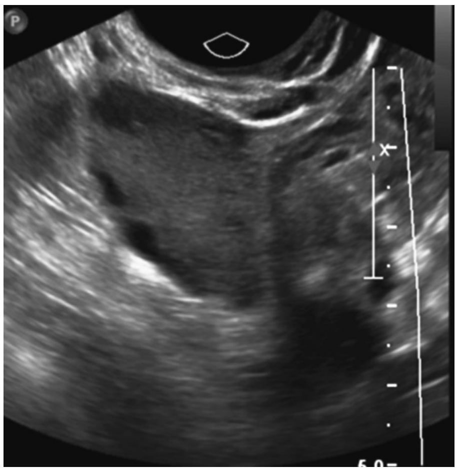


Fig. 6: Transvaginal ultrasound of the ovary

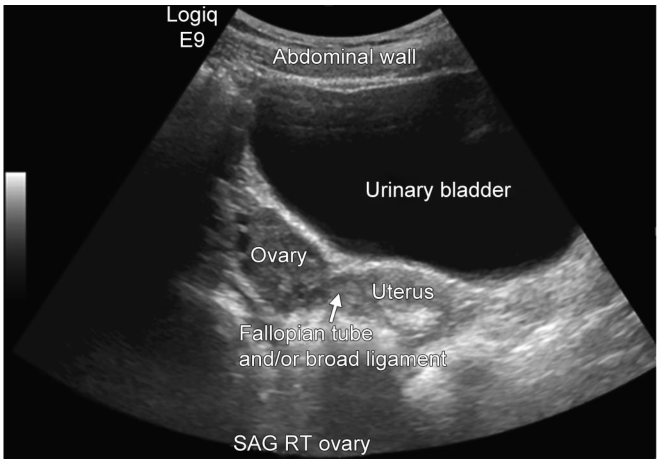


Fig. 7: Transabdominal ultrasound of the ovary. Identify urinary bladder, abdominal wall, ovary, uterus and broad ligament/fallopian tube

Discussion

Figures 5 and 6 demonstrate transabdominal and transvaginal scans of normal ovaries. The learners should recognize that the ovaries have relatively hypoechoic, scattered coarse pattern compared to the uterine myometrium (Fig. 7). The ovarian cortex contains follicles in varying stages of the development. Developing follicles are anechoic and of different size (Fig. 8). Ovaries are located in true pelvis, although exact position is variable. Their location is affected by parity, bladder filling, uterine size and position. Laxity in ligaments allows for limited mobility.

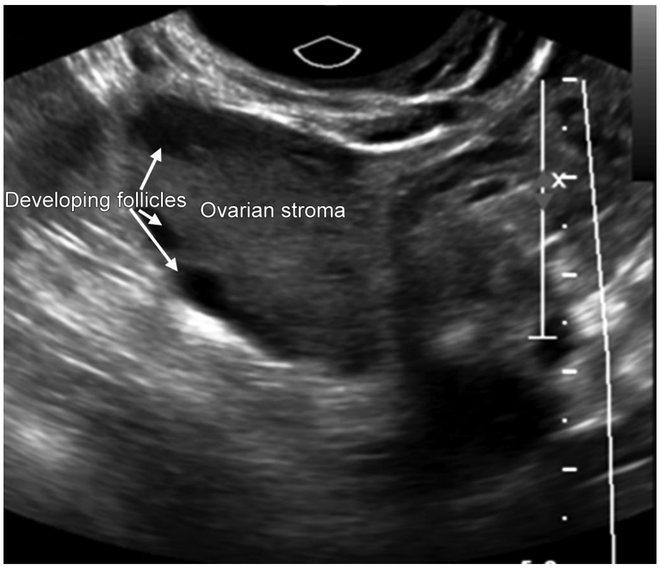


Fig. 8: Transvaginal ultrasound of the ovary. Note ovarian stroma and developing follicles

Case 3

A 25-year-old female with no significant past medical history complains of moderate acute pelvic pain. Transvaginal ultrasound was performed and findings are shown in Figure 9.

Discussion

A hemorrhagic cyst is formed when there is a hemorrhage into a follicular or corpus luteum cyst. Hemorrhagic cyst is visualized as a well-defined cystic lesion. Internal clumped echoes, concave or sharp angular shaped borders are consistent with retracting clot. Presence of internal innumerable reticular or linear echoes with a 'fishnet or lace-like' appearance is consistent with fibrin strands. The patient's abdomen and/or pelvis may be tender to direct pressure. Color Doppler typically does not reveal blood flow within the retracting clot and/or fibrin strands. Follow-up with ultrasound may not be necessary if the appearance is typical and size is less than 5 cm. For cysts with doubtful morphology and those that are larger than 5 cm follow-up should be recommended in 6 to 10 weeks.[1,2]

Case 4

A previously healthy 15-year-old female presents with worsening right lower quadrant abdominal pain, anorexia,

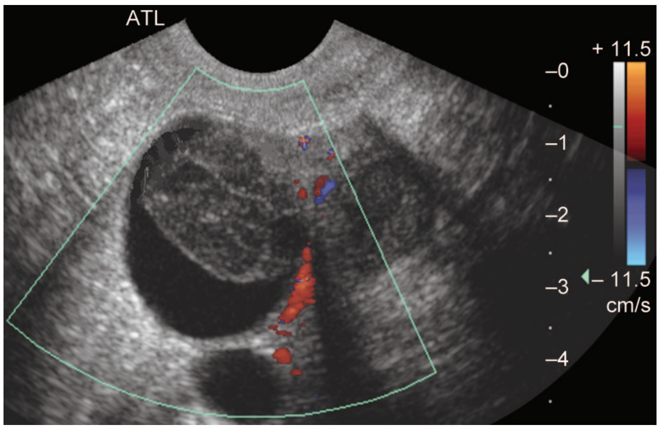


Fig. 9: Transvaginal ultrasound of the adnexa. Note cystic structure with a well-defined wall, internal reticular and linear echoes and no internal flow on color Doppler. Findings are consistent with hemorrhagic cyst

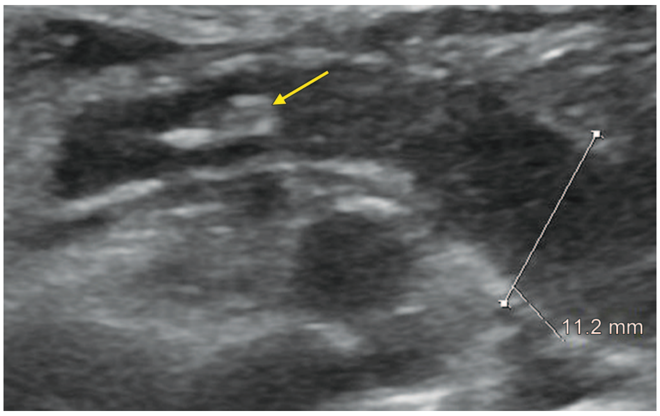


Fig. 10: Transabdominal ultrasound of right lower quadrant reveals a tubular sonolucent structure measuring 11.2 mm in its maximum diameter. An echogenic appendicolith with mild posterior shadowing is visualized in the proximal lumen (pointed by an arrow)

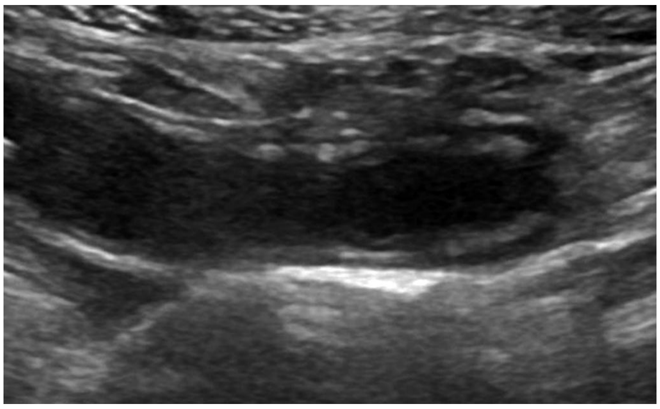
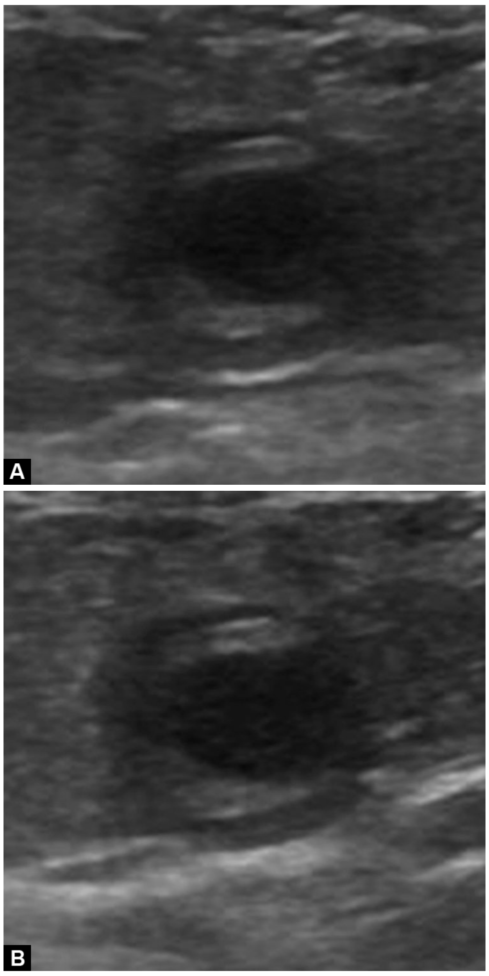


Fig. 11: The same structure visualized in longitudinal plane. Note thickened and hyperechogenic wall, suggestive of dilated appendix

nausea, vomiting, fever and an increased WBC count of 17,000 per mm^3. Transabdominal ultrasound was performed (Figs 10 to 12).

Discussion

The blind-ending tubular structure in Figure 10 is the appendix, which is markedly dilated (11.2 mm in diameter).



Figs 12A and B: Transverse section of the same structure before (A), and postcompression (B). Compression test confirmed non-compressible and inflamed appendix

An echogenic appendicolith with mild posterior shadowing is visualized in the proximal lumen (pointed by an arrow). Figure 11 demonstrates longitudinal plane of the same structure, while Figures 12A and B demonstrate non-compressibility of the inflamed appendix. In a young female patient, differential considerations of pelvic and adnexal pathology should always include the possibility of appendicitis. Appendicitis is one of the most common causes of abdominal pain that leads to emergent surgery.[3,4] Ultrasound has become a valuable tool in diagnosing appendicitis in young patients because it excludes the use of ionizing radiation.

Appendicitis is a result of luminal obstruction of the appendix. Obstruction leads to subsequent inflammation, superimposed infection, ischemia and eventual perforation. A graded-compression technique is used to identify the appendix, where gentle compression displaces normal bowel. The best ultrasound imaging clue of appendicitis is a dilated, noncompressible blind-ending tubular structure, which may be hypervascular with adjacent inflammatory changes. In a significant majority of patients an appendicolith may also be seen (20-40%).[3] One of the most important imaging findings includes the size criterion of a luminal diameter greater than 6 mm, which is highly suggestive of appendicitis (reported sensitivity of 98%); however, many patients may also have a normal appendiceal diameter greater than 6 mm.[3] That is why it is important to consider other supportive findings and the entire clinical picture when making the diagnosis. Color Doppler images may show peripheral wall hyperemia, reflecting inflammatory perfusion, yet this may not always be a reliable sign in advanced cases when ischemia limits flow to the appendix. Further supportive findings include adjacent inflammatory changes seen as echogenic, periappendiceal fat and adjacent surrounding hyperemia.[4]

Appendiceal perforation is suspected when the appendix demonstrates irregular contour, right lower quadrant gas (seen as dirty posterior shadowing), or when peri-appendiceal fluid collections are visualized.[3] However, perforated appendix may be easily missed because in these cases the appendix is usually decompressed. Nonetheless, transverse images usually demonstrate a round, inflamed appendix. When sonographic findings are equivocal, further examination with contrast-enhanced CT should be considered.

Case 5

A 62-year-old Caucasian female presents with abdominal discomfort, pelvic pain and bloating. Her last menstrual period was 12 years ago. Her labs were normal and the rest of her medical examination was noncontributory. Pelvic ultrasound and subsequent CT of the abdomen and pelvis with IV contrast were performed (Figs 13 to 15).

Discussion

Ultrasound images demonstrate a large multiloculated right adnexal mass (Figs 13 and 14) with thick, irregular septations and a large cystic component with low level echoes. Color Doppler image demonstrates vascularity within the septations (Fig. 14). Corresponding sagittal CT of the abdomen and pelvis demonstrates similar findings (Fig. 15). The mass encompasses the majority of the pelvis with extension into the abdomen. It is largely cystic with thick, enhancing, irregular internal septae.

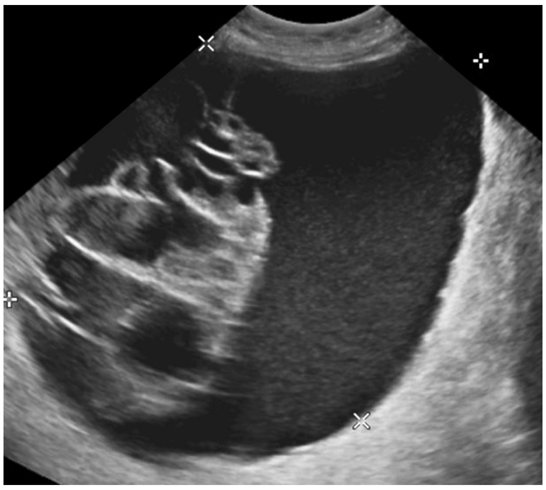


Fig. 13: Transabdominal pelvic ultrasound of right adnexal mass measuring 22.5 × 17.4 cm

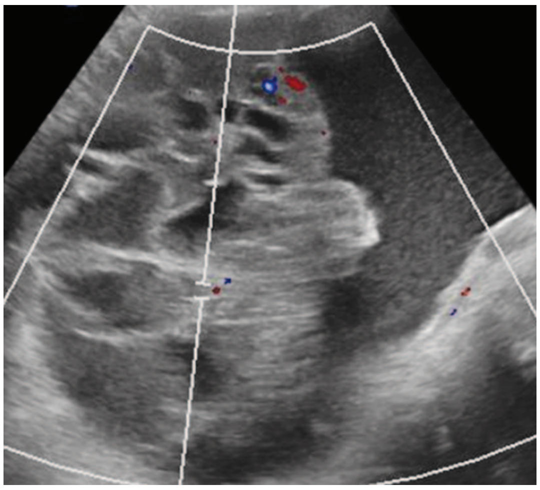


Fig. 14: Color Doppler image of the same adnexal mass. Vascular signals are depicted at the periphery and within the septate structures

Fig. 15: Sagittal CT of the abdomen and pelvis

At the time of surgery, this patient was diagnosed with a mucinous ovarian cystadenoma. Imaging characteristics and menopausal status are always important when considering the management of complex adnexal masses. According to a consensus panel consisting of specialists in radiology, pathology and gynecology, adnexal cysts can be divided into the following categories: normal, cysts with benign characteristics, cysts with indeterminate but probably benign characteristics, and cysts worrisome for malignancy.[5] This patient clearly has a complex adnexal lesion worrisome for malignancy.

These worrisome features include thick septations (≥3 mm), solid elements with flow on Doppler US, and focal areas of wall thickening (≥3 mm), particularly when seen in association with moderate to large amounts of ascitic fluid in the pelvis or peritoneal/omental implants.[5] Complex adnexal masses should be recommended for surgical evaluation. When cysts are too large to be imaged with ultrasound, further evaluation with CT or MRI should be recommended to evaluate the extent of the disease.[6] Some of the largest tumors in the literature are mucinous cystadenomas and/or cystadenocarcinomas. The sagittal reconstructed CT in Figure 15 impressively demonstrates the extent of this tumor.

Approximately 90% of all ovarian cancers are epithelial. Mucinous tumors are the second most common ovarian epithelial neoplasm (10%) after serous tumors (75-80%).[7] This patient demonstrated the typical imaging features, a multilocular cystic mass with low-level echoes. A potential form of peritoneal spread includes pseudomyxoma peritonei, in which there is abundant production of mucin within the peritoneal cavity by tumor cells.[6] This immediately upstages the neoplasm and portends a worse prognosis. Clearly, the main differential consideration includes serous cystadenocarcinoma. In these patients primary treatment is surgery, with complete staging laparotomy and tumor debulking as well as chemotherapy.

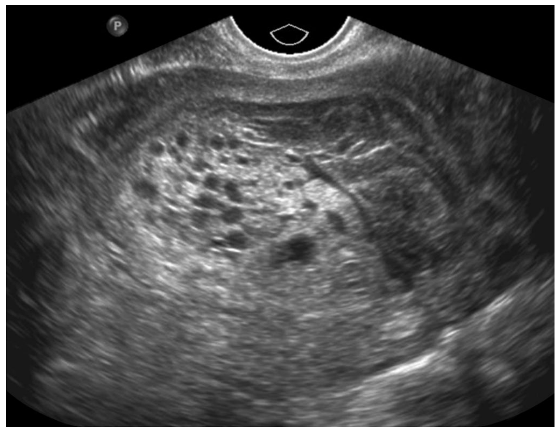


Fig. 16: Sagittal transvaginal ultrasound of the uterus

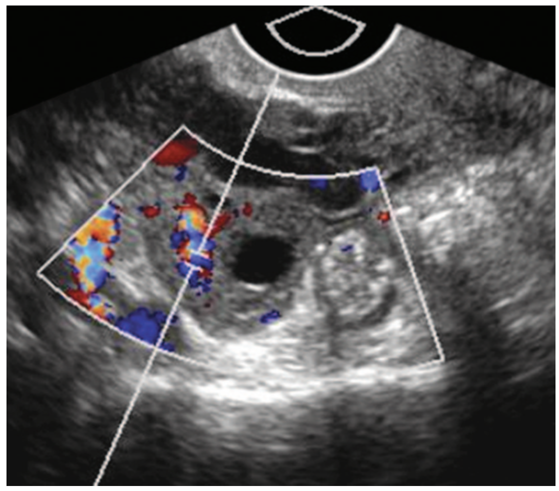


Fig. 17: Transvaginal color Doppler image of the right ovary

Case 6

A previously healthy 28-year-old Hispanic female presents with heavy vaginal bleeding for 2 days and lower abdominal pain. Her last menstrual period was 3 months ago. Her serum beta hCG level is 280,000 mIU/ml. She has had two prior spontaneous abortions. Her medical history is otherwise noncontributory. Transvaginal ultrasound was performed and images images are presented in Figures 16 and 17.

Figure 16 demonstrates an enlarged uterus filled with hyperechoic, heterogeneous tissue, which contains multiple small anechoic cystic structures, which resemble a 'cluster of grapes' pattern. No fetal parts are visualized. Figure 17 demonstrates a thick-walled cyst of the right ovary, with increased peripheral vascularity, consistent with a corpus luteum cyst.

Discussion

The overall imaging findings are consistent with a complete hydatidiform mole, which was confirmed after surgical resection and pathology examination. Ultrasonography plays a crucial role in the diagnosis of a molar pregnancy. Complete hydatidiform mole is a benign form of gestational trophoblastic disease, in which there is an abnormal proliferation of pregnancy-associated trophoblastic tissue with malignant potential, in the absence of an ascertainable fetus or embryo.[8] The overall incidence of hydatidiform mole is approximately 1 in 1,000 to 2,000 pregnancies, with the most common form being complete hydatidiform mole. Risk factors include prior molar gestation, extremes of maternal age (i.e. age in teens or 40's-50's), multiple spontaneous abortions, and Asian, American Indian, African American, or Latin American descent.[9]

The imaging findings include a thickened endometrial cavity with multiple small anechoic spaces of varying size and shape (1-30 mm), which resembles a 'bunch of grapes'. Pathologically, these 'grapes' represent chorionic villi, which convert to a mass of cysts. These cystic spaces tend to be more uniform in size and smaller earlier in the gestation.[8] Color Doppler images of the mass tend to be very vascular with high velocity, low impedance blood flow. An important distinction from incomplete hydatidiform mole is that no fetal parts are visualized in complete hydatidiform mole.[10] The ovaries of our patient were slightly enlarged and contained small corpus luteum cysts. However, due to the very high beta-hCG levels associated with hydatidiform moles, 20 to 50% of cases demonstrate large theca lutein cysts, which appear as an enlarged multicystic ovary with a 'spoke-wheel' appearance.[8]

Some differential considerations include retained products of conception (hCG levels decrease with time, color Doppler reveals high velocity–low impedance blood flow, with no presence of placental venous lakes), incomplete abortion (would see fetal parts), and invasive mole/choriocarcinoma (B-mode ultrasound usually indistinguishable from molar pregnancy). Clinically, once diagnosed, these patients have an excellent prognosis after evacuation with suction curettage. However, invasive mole or chroriocarcinoma may develop in a minority of cases. Follow-up is recommended with serial beta-hCGs for 3 weeks, then monthly for 6 months. Contraception is also recommended for 6 months after the first normal hCG result, to distinguish a rising hCG from pregnancy versus recurrent or metastatic disease.[8]

Case 7

A 19-year-old pregnant female, G1 P0 presents to the emergency department with abrupt onset of pelvic pain that has lasted for 3 days. Gestational age by LMP is 14 weeks 6 days. Vital signs and laboratory values are unremarkable. Transabdominal and transvaginal ultrasound imaging reveals normal 14 weeks intrauterine pregnancy and unilateral left ovarian enlargement with a large simple appearing cyst (Figs 18A and B). The cyst measured 12.1 × 7.4 × 12.9 cm. Color Doppler does not reveal any blood flow signals.

Discussion

The imaging findings are consistent with ovarian torsion secondary to a simple cyst. Surgical and pathology reports demonstrated a cystadenoma with ovarian torsion. Adnexal torsion is defined as a twisting of the vascular pedicle causing reduced venous outflow and/or arterial inflow. The arterial supply to the adnexa includes the ovarian artery and the adnexal branch of the uterine artery. The veins are affected first, due to the lower pressures within the venous system. When ovarian torsion occurs there is fallopian tube involvement in up to two thirds of the cases.[11] Torsion is commonly caused by an adnexal mass or cyst that is greater than 5 cm in diameter.[12] Patients present with abrupt onset of pelvic pain that is usually unilateral. Ultrasound findings include unilateral ovarian enlargement with absence of venous and/or arterial flow on Doppler. The ovary may have small peripheral cysts adjacent to one another known as 'the string of pearls' sign.[12] The presence of flow on Doppler imaging does not exclude adnexal torsion. The presence of arterial flow on Doppler imaging may help with prognosis and the ovary may be able to be detorsed and preserved. A partial oophorectomy may be performed to remove the inciting mass or cyst. If arterial flow is absent the prognosis is poorer and necrosis is more likely upon surgical exploration.[13] Oophorectomy with or without salpingectomy may be the curative treatment.

Case 8

A 39-year-old female presents to the emergency department with acute pelvic pain, vaginal bleeding and a positive serum beta-hCG of 8,891 mIU/ml. Figures 19 and 20 illustrate her transvaginal ultrasound findings. Using transvaginal ultrasound an intrauterine pregnancy should be seen when beta-hCG is above 1,500 mIU/ml. In our patient there is no sonographic evidence of intrauterine pregnancy. In the right adnexal region there is a complex adnexal mass, clearly separated from the right ovary. Careful exploration of the posterior *cul-de-sac* reveals presence of free fluid (Fig. 20B).

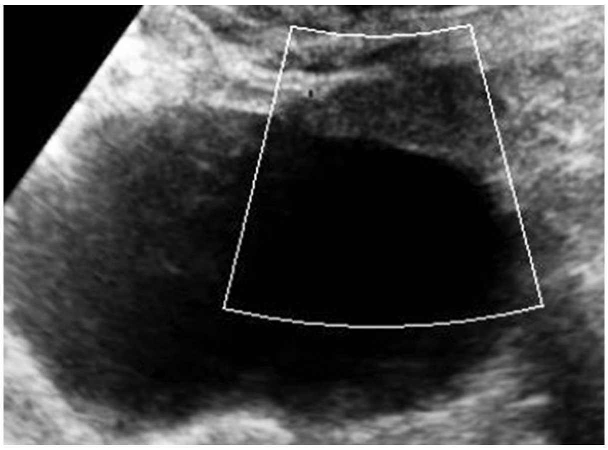


Fig. 18A: Transabdominal ultrasound of case #7

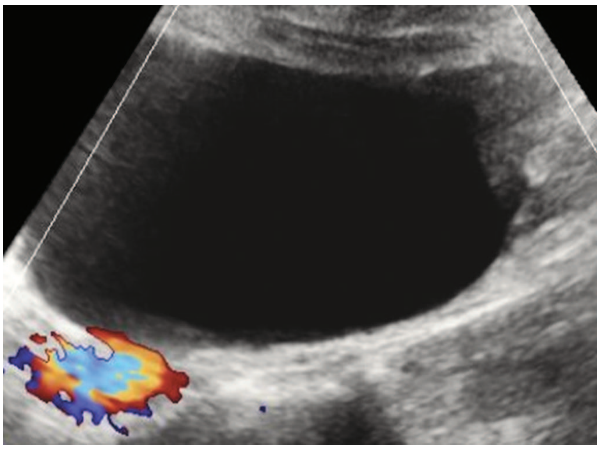


Fig. 18B: Transabdominal color Doppler image of the same patient as in Figure 18A

Fig. 19: Transvaginal ultrasound of the uterus does not demonstrate an intrauterine gestational sac

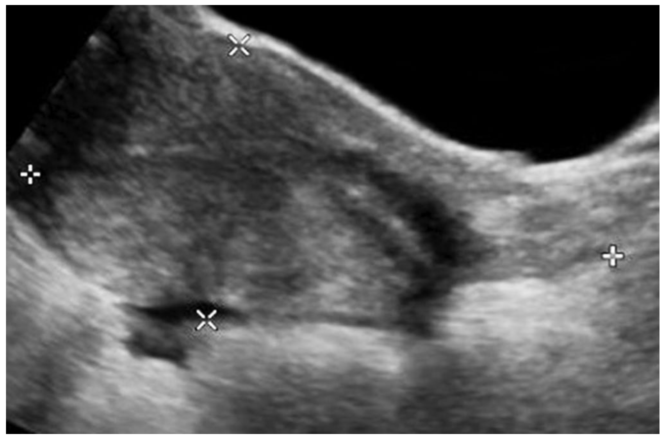


Fig. 21: Transabdominal ultrasound of the uterus. Small amount of free fluid is visualized in the anterior and posterior *cul-de-sac*

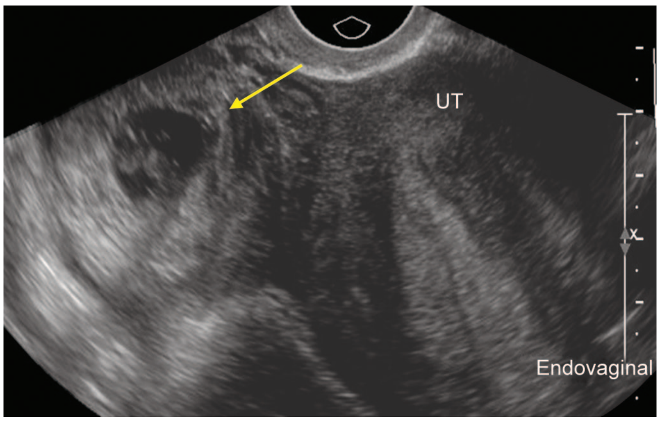


Fig. 20A: Transvaginal ultrasound of the right adnexal mass (pointed by an arrow). An empty uterus with thickened endometrium is visualized to the right

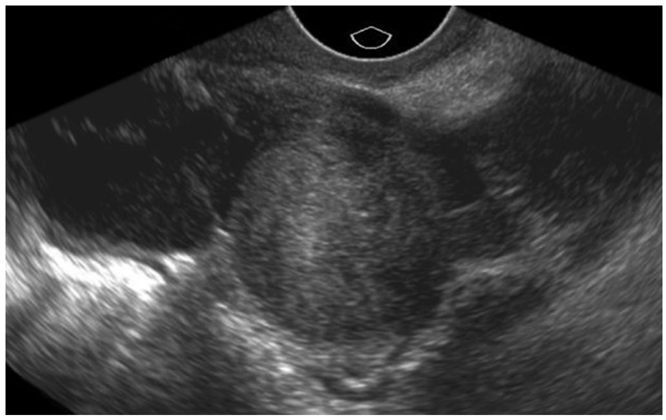


Fig. 22: Transabdominal ultrasound demonstrates normal size uterus and bilateral complex adnexal masses

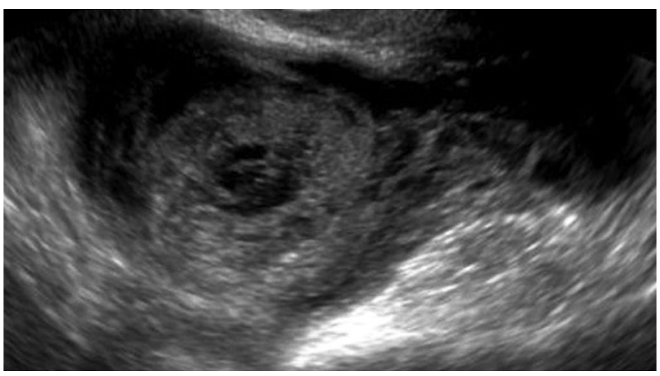


Fig. 20B: Free fluid is visualized in the posterior *cul-de-sac*, behind the right adnexal mass

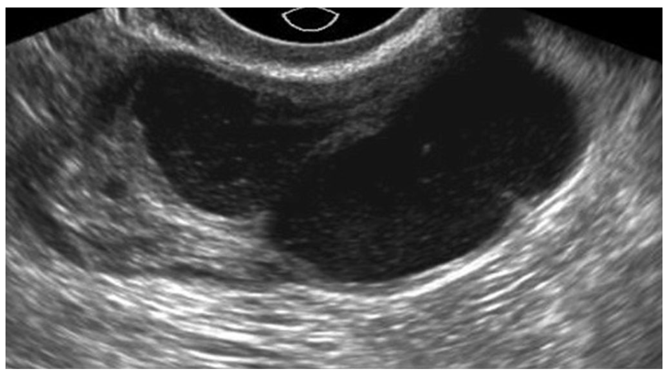


Fig. 23: Adnexal mass with thick walls and echogenic content

Discussion

Ectopic pregnancy represents abnormal implantation of an embryo outside the uterine cavity and occurs in approximately 2% of pregnancies.[14] In a female patient with pelvic pain, vaginal bleeding and a positive pregnancy test, the possibility of ectopic pregnancy should be evaluated.[15] Ultrasound is the preferred imaging choice. Typical ultrasound findings include the lack of an intrauterine gestational sac, presence of an adnexal mass separate from the ovary and presence of free fluid in the *cul-de-sac*. A gestational sac may be visualized transvaginally at serum beta-hCG levels approximately 1,500 mIU/ml, but local reference values must be used. The most common site of ectopic pregnancy is in the fallopian tube, so focused imaging should be performed in between the uterus and the ovary.[15] A large amount of fluid in the pelvis may represent a ruptured ectopic pregnancy. If the patient is unstable surgical management is indicated. In minimally symptomatic or asymptomatic patients, with gestational sac smaller than

3.5 cm and serum beta-hCG less than 5,000 mIU/ml medical management using methotrexate may be used. In patients with gestational sac diameter greater than 3.5 cm, presence of fetal cardiac activity, and serum beta-hCG greater than 5,000 mIU/ml conservative treatment is not recommended.[16] Multiple doses of methotrexate are sometimes required for patients with relative contraindications and there are higher rates of treatment failure. Methotrexate is used in combination with follow-up imaging and serial serum beta-hCG to treat and follow the course of the conservative treatment of ectopic pregnancy.

Case 9

A 28-year-old female presents to the emergency department with vaginal spotting for 1 week and pelvic pain and pressure for 1 day. Transabdominal and transvaginal ultrasound was performed and images are presented in Figures 21 to 23.

Discussion

Pelvic inflammatory disease (PID) is a spectrum of disease that may progress from endometritis, salpingitis, hydrosalpinx, pyosalpinx to tubo-ovarian abscess. The most common causes of PID are ascending infections from *Chlamydia trachomatis* and *Neisseria gonorrheae*. Patients with PID caused by Chlamydia may not have any clinical manifestations even though damage is occurring. Common presenting symptoms of PID include pelvic or lower abdominal pain, vaginal discharge and fever. The diagnosis may be made clinically (cervical motion tenderness) and/or with laboratory and microscopic findings. Ultrasound may be used to evaluate the spectrum of the disease or to look for other causes of pelvic pain. In early PID ultrasound findings may be normal. Early ultrasound findings may be subtle with increased pain on examination, fluid within the endometrial cavity and thickening of the endometrium. Other findings include uterine enlargement and the ovaries may have edematous changes with increased prominence of cysts. Fluid may be present in the adnexa. More pronounced changes include dilated fallopian tubes that may be filled with fluid, pus, blood and debris.[16] Ultrasound can demonstrate the dilated fallopian tubes extending from the uterus to the adnexa without peristalsis distinguishing the tubes from bowel. The fallopian tubes may have a tortuous course with areas of linear projections into the lumen secondary to folding of the tube. The tube may have an anechoic lumen from fluid and exudates or have increased echogenicity from denser fluids and debris. Complications from PID include infertility, ectopic pregnancy and chronic pelvic pain.[17,18]

REFERENCES

1. Lambert MJ, Villa M. Gynecologic ultrasound in emergency medicine. Emerg Med Clin North Am 2004;22(3):683-696.
2. Vandermeer FQ, Wong-You-Cheong JJ. Imaging of acute pelvic pain. Clin Obstet Gynecol 2009;52(1):2-20.
3. Rybkin AV, Thoeni RT. Current concepts in imaging of appendicitis. Radiologic Clinics of North America 2007;45(3):411-422.
4. Sivit CJ, Siegel MJ, Applegate KE, Newman KD. When appendicitis is suspected in children. Radiographics 2001;21(1):247-262.
5. Levine D, Brown DL, Andreotti RF, Benacerraf B, Benson CB, Brewster RW, Smith-Bindman R. Management of asymptomatic ovarian and other adnexal cysts imaged at US: Society of Radiologists in Ultrasound Consensus Conference Statement. Radiology 2010;256(3):943-954.
6. Woodward PJ, Hosseinzadeh K, Saenger JS. From the archives of the AFIP: radiologic staging of ovarian carcinoma with pathologic correlation. Radiographics 2004;24(1):225-246.
7. Holschneider CH, Berek JS. Ovarian cancer: epidemiology, biology, and prognostic factors. Semin Surg Oncol 2000;19(1):3-10.
8. Green CL, Angtuaco TL, Shah HR, Parmley TH. Gestational trophoblastic disease: a spectrum of radiologic diagnosis. Radiographics 1996;16(6):1371-1384.
9. Lurain JR. Gestational trophoblastic disease 1: epidemiology, pathology, clinical presentation and diagnosis of gestational trophoblastid disease, and management of hydatidiform mole. Am J Obstet Gynecol 2010;203(6):531-539.
10. Zhou Q, Lie XY, Cardoza JD. Sonographic and Doppler imaging in the diagnosis and treatment of gestational trophoblastic disease: a 12-year experience. J Ultrasound Med 2005 24(1):15-24.
11. Albayram F, Hamper UM. Ovarian and adnexal torsion: spectrum of sonographic findings with pathologic correlation. J Ultrasound Med 2001;20(10):1083-1089.
12. Chang HC, Bhatt S, Dogra VS. Pearls and Pitfalls in Diagnosis of ovarian torsion. Radiographics 2008;28(5):1355-1368.
13. Lee EJ, Kwon HC, Joo HJ, Suh JH, Fleischer AC. Diagnosis of ovarian torsion with color Doppler sonography: depiction of twisted vascular pedicle. J Ultrasound Med 1998;17(2):83-89.
14. National Center for Health Statistics. Advanced report of final mortality statistics. US Department of Health and Human Services, Public Health Service 2010. Available at: http://www.cdc.gov/nchs/data/hus/hus10.pdf (accessed July 26, 2013).
15. Levine D. Ectopic pregnancy. Radiology 2007;245:385-397.
16. American College of Obstetricians and Gynecologists (ACOG). ACOG Practice Bulletin No. 137, 2013. Available at: http://www.acog.org/~/media/List%20of%20Titles/PBListOfTitles.pdf (accessed on July 26, 2013).
17. Potter AW, Chitra A, Chandrasekhar MB. US and CT evaluation of acute pelvic pain of gynecologic origin in nonpregnant premenopausal patients. Radiographics 2008;28:1645-1659.
18. American College of Obstetricians and Gynecologists (ACOG). Pelvic Inflammatory Disease. Frequently Asked Questions (FAQ077). Available at: http://www.acog.org/~/media/For%20Patients/faq077.pdf?dmc=1&ts=20130726T1515262484 (accessed on July 26, 2013).