Benign and Malignant Adnexal Masses on Ultrasound, CT, and MRI

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Agenda

• Introduction to our patient
• Relevant anatomy
• Our patient’s CT findings
• Menu of tests
• Differential for adnexal masses
• Findings on ultrasound
• Examples of MRI evaluation
• Our patient revisited: Gross pathology
• Final diagnosis: Ovarian carcinoma
Introduction to our patient

- Our patient is a 40 year old, gravida 1, para 1 female who presented with several days of nausea and bloating.

- She has had a past medical history of bilateral breast cancer, status post lumpectomy and radiation.

- Family history is significant for breast and ovarian cancer in her mother and her maternal aunt.

- On physical exam, she has a distended abdomen with a positive fluid wave, a mass palpable in the left lower quadrant, and fullness of the uterus on bimanual pelvic exam.
Before viewing our patient’s CT findings, let’s review some basic anatomy of the pelvic cavity.
Relevant anatomy: Pelvic cavity

View the diagram of normal pelvic anatomy, and compare it to the CT of a normal patient on the right.

McKinley & O’Loughlin, 2007

Companion patient 1
Sagittal C+ CT; PACS, BIDMC
Here, normal pelvic structures are outlined on the normal patient’s CT. The **pubic symphysis** is in **yellow**, the **bladder** is in **green**, the **uterus** is in **blue**, and the **rectum** is in **orange**.
Our patient's CT: Compare with a normal CT

Let’s view our patient’s CT on the right. Companion patient 1, whose normal CT was seen previously, is provided for comparison.

Where are the normal structures on our patient’s sagittal CT?
The **pubic symphysis**, **bladder**, and **rectum** are highlighted. The **uterus** is difficult to differentiate from a large, heterogeneous **mass**, highlighted with a **purple star**. She also has fluid-level density in the abdominal cavity (**orange arrow**), representing **ascites**.
Coronal CT: Normal structures

We can also compare our patient to a normal patient’s CT on coronal view. On the left, we see normal **bladder** and **uterus**, highlighted with **green** and **blue** arrows, respectively.
Coronal CT: Our patient’s findings

On our patient’s CT on the right, the uterus is visible (blue arrow). There is a large heterogeneous mass on the left (orange arrow), and a multicystic mass with solid components on the right (purple arrow). In addition, ascites (yellow arrow) can be seen.
Axial CT: Adnexal masses

Here are axial views of our patient’s CT. The uterus (yellow arrows) is visible, flanked by two irregular masses (orange arrows). There is also prominent ascites (green arrows).
Ascites is also visible in these sections of our patient’s axial CT.
Here we see ill-defined density abutting the anterior abdominal wall on our patient’s axial CT, suggestive of omental caking (orange arrow). Omental caking is abnormal thickening of the omentum, due to infiltration by tumor. The thick and nodular appearance of omental caking can be seen on the CT of companion patient 2 (short white arrow).
Axial CT: Lymphadenopathy

Here, we see on axial CT that our patient also has markedly enlarged pelvic lymph nodes (green arrows), which measured up to 17 mm in diameter. The uterus (yellow arrow) is also visible.
Here, we see prominent para-aortic lymph nodes (green arrows) and peritoneal enhancement (yellow arrows). Peritoneal enhancement is a sign of peritoneal inflammation, such as with malignant infiltration.
CT findings: Summary

• In summary, our patient’s CT showed:
  - Large, bilateral adnexal masses
  - Moderate ascites
  - Omental caking
  - Pelvic lymphadenopathy
  - Perioneal enhancement

• These findings are highly concerning for malignancy, with involvement of the peritoneum, omentum, and regional lymph nodes.

• The main findings were the large adnexal masses; next we will discuss the different radiologic tests for evaluating adnexal masses.
Menu of tests: Ultrasound

- **Ultrasound**
  - This is the first line test for detecting, localizing, and characterizing adnexal masses.
  - 90% of adnexal masses are correctly classified as benign vs. malignant on ultrasound.
  - Many types of adnexal masses have typical characteristics on ultrasound, and are reliably recognized.
  - No ionizing radiation, widely available, and low cost
  - There are two forms of pelvic ultrasound:
    - Transabdominal – better tolerated, can evaluate abdominal processes; performed with distended bladder
    - Transvaginal – better resolution of pelvic structures, less artifact

- Magnetic Resonance Imaging (MRI)
- Computed Tomography (CT)
- Positron Emission Tomography (PET) scanning
Menu of tests: Magnetic resonance

- Ultrasound
- **Magnetic Resonance Imaging (MRI)**
  - Is used for further evaluation when ultrasound is indeterminate
  - Is useful for large masses, masses in the superior or lateral pelvis, masses with atypical ultrasound features, or masses of unclear origin (for example, uterine vs. ovarian)
  - Can differentiate between blood products (as in hemorrhagic cysts or endometrioma) and solid mass
- Computed Tomography (CT)
- Positron Emission Tomography (PET) scanning
Menu of tests: Computed tomography

- Ultrasound
- Magnetic Resonance Imaging (MRI)
- **Computed Tomography (CT)**
  - Is generally used to evaluate spread of ovarian malignancy, i.e. staging
  - Not as specific as ultrasound in differentiating between benign masses
  - May be useful if non-pelvic source of malignancy suspected
  - May be useful for evaluating tubo-ovarian abscess, by visualizing contiguous inflammatory changes
- Positron Emission Tomography (PET) scanning
Menu of tests: PET scanning

• Ultrasound
• Magnetic Resonance Imaging (MRI)
• Computed Tomography (CT)
• **Positron Emission Tomography (PET) scanning**
  • Not currently indicated for preoperative characterization of adnexal masses
  • Not widely available
  • May be useful in staging recurrent cancer
Menu of tests: Comparing modalities

Below are the sensitivities and specificities of various modalities of evaluation for differentiating between benign and malignant masses (Myers et al., 2006):

- bimanual exam 45 and 90 percent
- ultrasound morphology 86 to 91 and 68 to 83 percent
- combined ultrasound morphology and Doppler 86 and 91 percent
- magnetic resonance imaging 91 and 88 percent
- computed tomography 90 and 75 percent
- PET scan 67 and 79 percent
- CA-125 78 and 78 percent
Next, we will view characteristic findings of adnexal masses on ultrasound. But first, let’s review some basic anatomy relevant to the ovary.
The ovaries are suspended on either side of the uterus in the peritoneal cavity. The broad ligaments, consisting of two layered folds of peritoneum, run between the uterus and the lateral pelvic walls.

Other ligamentous connections between the ovaries, uterine tubes, and the surrounding structures are the mesosalpinx, the mesovarium, the ovarian ligament, and the suspensory ligament of the ovary.
This diagram shows the progression of the ovarian follicle from a primordial follicle, to a primary follicle, to a secondary follicle.

The matured follicle eventually ruptures to release the oocyte, and the follicle remnants become the corpus luteum, which releases progesterone.

If no fertilization event occurs, the corpus luteum involutes into white fibrous tissue (corpus albicans), and the next cycle of ovulation continues.
Ultrasound: Normal ovary

Next, we will view the appearance of the normal ovary on ultrasound.

- A normal follicle in premenopausal women appears as a <20-25 mm simple, anechoic, fluid filled cyst.

Normal ovary appearance:
Reproductive age
Follicles
- Thin and smooth walls
- Round or oval
- Anechoic
- Size ≤ 3 cm
- No blood flow

Companion patient 3, Levine et al., 2010
A normal corpus luteum appears as a cystic mass with a thick, crenulated wall and peripheral blood flow, or “ring of fire”.

Companion patient 4, Levine et al., 2010
Ultrasound: Normal postmenopausal ovary

- Here is the characteristic appearance of a postmenopausal ovary, which is small and homogenous in echotexture.

Normal ovary appearance: Postmenopausal
- Small
- Homogenous
The following is a differential for various adnexal masses that may be seen on ultrasound. We will view examples of several of these.

Given our patient’s history of cancer and findings on CT, we are most concerned about malignant masses.
Differential for adnexal masses on ultrasound

- Physiologic/functional cysts
  - Follicular cyst
  - Corpus luteum cyst
  - Hemorrhagic cysts

- Polycystic ovary syndrome

- Pregnancy-related:
  - Ectopic pregnancy
  - Theca lutein cysts
  - Corpus luteum of pregnancy
  - Luteoma

- Inflammatory:
  - Hydrosalpinx/pyosalpinx
  - Tuboovarian abscess or complex

- Benign ovarian neoplasms
  - Serous and mucinous cystadenoma
  - Mature cystic teratoma (dermoid cyst)
  - Ovarian fibroma
  - Endometrioma

- Malignant ovarian neoplasms
  - Epithelial
  - Germ cell tumors
  - Sex cord-stromal tumors
  - Metastatic tumors (breast, GI, endometrium)

- Extraovarian masses
  - Pendunculated uterine leiomyoma
  - Paraovarian/paratubal cysts
  - Peritoneal inclusion cyst
Benign findings: Simple cyst

Below is an example of a simple cyst. These are usually follicular cysts that have not ruptured and are filled with fluid. These are rarely malignant, and most will resolve on their own in 1-2 months.

Characteristics of simple cysts:
- Anechoic
- Smooth, thin walls
- No internal flow on Doppler
- Posterior acoustic enhancement

Companion patient 6; PACS, BIDMC
Benign findings: Hemorrhagic cyst

These are examples of hemorrhagic cysts, which are often caused by bleeding into a corpus luteum. Most resolve in 6-8 weeks.

Characteristics of hemorrhagic cysts:

- Reticular pattern of internal echoes (fibrin strands)
- Posterior acoustic enhancement
- No internal flow on Doppler
- **Clot** (marked with C on companion patient 9) may be mistaken for solid neoplasm, but has no internal flow and has concave margins (green arrow).
Benign findings: Endometrioma

This is an example of an endometrioma, which consists of ectopic endometrial tissue.

Characteristics of endometriomas:

- Diffuse, homogenous, low-medium level internal echoes
- Ground glass appearance
- Usually no solid component, though a clot or endometrial tissue may appear to be a small solid area
Benign findings: Dermoid cyst

The above are examples of dermoid cysts, or mature cystic teratomas.

**Characteristics of dermoid cysts:**
- Focal or diffuse **hyperechoic component (green arrow)** with distal acoustic shadowing (may represent fat; highly predictive of dermoid cysts)
- Hyperechoic lines and dots, called **dermoid mesh** (**orange arrow**; may represent different tissues within teratoma, for example hair)
- No internal flow on Doppler
- May see a fluid-fluid level, with the echogenic component layering nondependently (floating fat)
Ultrasound findings suggestive of malignancy

We’ve reviewed examples of benign masses on ultrasound. In contrast, the following are signs that a mass is concerning for malignancy:

- **Solid** components (may be nodular or papillary) – the most important predictor
- Thick **septations** (>2-3 mm)
- **Flow** in solid component/septa seen on color or power Doppler
- **Ascites** (suggestive of peritoneal spread of the malignancy)
- Peritoneal masses, lymphadenopathy, matted bowel
Signs of malignancy: Solid components

Companion patient 13: Serous cystadenocarcinoma
Brown et al., 2010

Companion patient 14: Nodule with blood flow
Levine et al., 2010

The above are examples of cystic masses with **solid components (white arrow)**, which also demonstrate **flow on Doppler (green arrows)**. Solid components are the most predictive characteristic for malignancy, though benign lesions can have solid areas as well. The majority of epithelial ovarian malignancies have both cystic and solid components.
Signs of malignancy: Thick septations

The above demonstrate **thick septae (white arrows)** within cystic masses. Thin septae can be seen in benign lesions, but many septae that are thicker than 2-3 mm and demonstrate flow on Doppler are worrisome for malignancy.
Here is our patient’s ultrasound. Note the large left adnexal mass (labeled \textit{lt adx}), the irregular appearing right ovary (\textit{rt o}) with cystic components (green arrow), and the uterus (\textit{ut}).
Our patient’s ultrasound: Color Doppler

Here are more images from our patient’s pelvic ultrasound, this time with color Doppler. As our patient is premenopausal, the cystic areas in the right ovary could represent normal follicles, however the solid portions of the ovary appear irregular and demonstrate flow on Doppler (yellow arrow). There is also abundant vascularity (green arrow) in the left adnexal mass. Again, vascularity within solid components is highly concerning for malignancy.
Before continuing with our patient’s case, let’s view some examples of how MRI can be used to evaluate adnexal masses.
This patient is a 57 year old female who had a pelvic cyst on spinal MRI. Here, on the precontrast T1 weighted image, we see a large cystic mass (yellow arrows), though the interior of the mass is not well defined.
Companion patient’s MRI: Postcontrast

This is the same level on the MRI after administration of gadolinium. Now we can see enhancing septations (green arrow) on the interior of the mass.
Companion patient’s MRI: Subtracted

This is the subtracted image (subtracting the precontrast image from the postcontrast image), which confirms the enhancement of the internal septations.
Evaluation with MRI: Septations

Here are our companion patient’s T1W MRI images again, side by side. We can see the septations in the mass enhance clearly after administration of gadolinium contrast. These are still seen on the subtracted image, which confirms the enhancement.
Companion patient’s MRI: T2W

• Here is the T2 weighted image for patient 17. On T2W imaging, the septations (green arrows) are well visualized due to high signal from the cystic fluid.

• The appearance of this cystic mass with multiple, smooth, thin septa and no nodularity is consistent with mucinous cystadenoma, a benign epithelial neoplasm. This was subsequently confirmed on pathology.

• Various types of masses and tissues can be similarly differentiated on MRI based on signal intensity characteristics and appearance with contrast.
Here is another example of how MRI can be used to characterize adnexal masses. This patient is a 73 year old female who was evaluated for large cysts found on ultrasound and an elevated CA-125.

On this precontrast axial MRI, we see a complex cystic mass with solid components. To further characterize the solid-appearing area (green arrow), we will see how this area responds to administration of contrast.
On the postcontrast image (left), it is difficult to tell whether the solid area (green arrows) is enhancing. On the subtracted image (above), however, we see that the area clearly enhances with gadolinium.
In contrast, here is a different area in the same complex cystic and solid ovarian mass. This *area (yellow arrow)* appears to have a moderate signal on precontrast imaging.
Evaluate the same area (yellow arrows) again on post-gadolinium (left) and subtracted images (above). On the postcontrast image the area could be enhancing, but on the subtracted image we clearly see that the area does not enhance.
Evaluation with MRI: Summary

With companion patient 18, we saw how MRI can be used to differentiate areas within a complex mass based on contrast-enhancement qualities. This patient was found to have endometrioid carcinoma with clear cell components.

Based on patterns of enhancement and signal intensities, MRI can be used to accurately identify various masses based on morphologic criteria. It is also useful for differentiating hemorrhagic clot from solid tissue, which can be difficult to differentiate on ultrasound.
Our patient underwent exploratory laparotomy, during which tumor was found in both ovaries, with metastases to the uterus, pelvic and para-aortic lymph nodes, posterior cul-de-sac, omentum, pelvic side walls, and a right diaphragm nodule.

She then underwent bilateral salpingo-oophorectomy, total abdominal hysterectomy, radical resection of the pelvic and abdominal tumor, total pelvic lymphadenopathy, bilateral periaortic lymph node resection, and infragastric omentectomy. 3 liters of ascites were drained.
Gross pathology: Intraoperative

On the left is an intraoperative photograph of our patient’s hysterectomy. The anterior surface of the uterus (green arrow) is visible, surrounded by masses (blue arrows).

Courtesy of Leo Tsai, MD, PhD, MSc
Gross pathology: Intraoperative, cont.

Here we see our patient’s left adnexal mass (blue arrow).

Courtesy of Leo Tsai, MD, PhD, MSc
Pathological correlation: Left mass

Above is the gross appearance of our patient’s resected left adnexal mass, corresponding to our patient’s coronal CT (right) and transverse ultrasound (upper right), outlined in green.
Pathological correlation: Right adnexal mass

Here we see the gross appearance of our patient’s resected right ovary, correlating with the appearance on coronal CT (right, in green) and transverse ultrasound (middle). Note the cystic portions of the mass.
Above is the appearance of omental caking on our patient’s axial CT. On the left are images of our patient’s resected omentum, which was found to be infiltrated with tumor.
These are microscopic sections of our patient’s left adnexal mass, which was graded as G3, poorly differentiated. The papillary architecture of the tissue (left) and psammoma bodies (calcifications, blue arrows) are characteristic of serous papillary ovarian adenocarcinoma.
Ovarian cancers

- Ovarian cancers are the 2nd most common gynecological malignancy, but the 5th leading cause of cancer death in all women.

- Risk factors: nulligravity, infertility, endometriosis, hereditary ovarian cancer syndromes (BRCA, Lynch syndrome)

- The majority of ovarian cancers are stage III or IV at time of diagnosis. Early symptoms are often vague and ill-defined, making early diagnosis difficult.

- Typical presentation: A fixed, irregular pelvic mass with upper abdominal mass and/or ascites

- Symptoms of advanced disease: abdominal distention, nausea, anorexia, or early satiety due to the presence of ascites and omental or peritoneal metastases
90% of ovarian cancers are epithelial.

Ultrasound is the most useful noninvasive diagnostic test in women with adnexal masses.

Serum CA-125 is often elevated in patients with ovarian cancer, but it is not specific, especially in premenopausal women. Of note, our patient’s CA-125 was 641 (normal <35 U/mL).

Surgery is needed to definitively diagnose, stage, and treat ovarian cancers.

The majority of patients will need both surgery and chemotherapy. Optimal cytoreduction (debulking of the tumor) at surgery is an important determinant of the success of systemic chemotherapy.
Staging guidelines

To the left are the staging guidelines from the FIGO for ovarian cancers. Our patient’s stage was pT3c (IIIC), as she had peritoneal metastases beyond the pelvis more than 2 cm and/or regional lymph node metastases.

Chen & Berek, 2010.
### Staging guidelines, cont.

#### Regional lymph nodes (N)

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<th>FIGO stages</th>
<th>Definition</th>
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<tr>
<td>N1</td>
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#### Distant metastasis (M)

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<td>M0</td>
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<td>No distant metastasis</td>
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<tr>
<td>M1</td>
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<td>Distant metastasis (excludes peritoneal metastasis)</td>
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**pTNM pathologic classification.** The pT, pN, and pM categories correspond to the T, N, and M categories.

#### Anatomic stage/prognostic groups

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*Note: cTNM is the clinical classification, pTNM is the pathologic classification.*

* Liver capsule metastasis T3/Stage III: liver parenchymal metastasis M1/Stage IV. Pleural effusion must have positive cytology for M1/Stage IV.

*Used with the permission of the American Joint Committee on Cancer (AJCC), Chicago, Illinois. The original source for this material is the AJCC Cancer Staging Manual, Seventh Edition (2010) published by Springer New York, Inc.*

Chen & Berek, 2010.
Our patient’s history

Our patient had a strong personal history of breast cancer, and a strong family history of breast and ovarian cancers.

This brings up the question of whether she may have had a hereditary breast/ovarian cancer syndrome, such as a BRCA mutation.

Her presenting symptoms developed a few weeks before she was to be tested for BRCA mutations.
Ovarian cancer and BRCA

- Having a history of breast cancer or family history of breast or ovarian cancer increases the risk of developing ovarian cancers by 2-6 times.

- BRCA mutations are thought to be responsible for 90% of hereditary ovarian cancers, and 10% of all ovarian cancers.

- BRCA1 carriers have a 30-60% chance of developing ovarian cancer by age 70.

- Screening with transvaginal ultrasound and serum CA-125 every 6-12 months is recommended for BRCA carriers.

- Oopherectomy is known to be protective in mutation carriers.
Summary

- Ultrasound is the first line modality for detecting and evaluating adnexal masses.
- The majority of adnexal masses are benign.
- Characteristics suggestive of malignancy are solid components in a cystic mass, thick septations, ascites, and color Doppler flow in solid areas or septae.
- Ovarian cancer has the highest mortality of the gynecological malignancies, and typically does not present until stage III or IV.

- A common presentation of ovarian cancer is a fixed, irregular pelvic mass with ascites.

- Patients with history of breast cancer or family history are at higher risk, and for patients with hereditary syndromes, regular screening and oopherectomy may be indicated.
References

BIDMC PACS and Online Medical Records.

Chen, LM, and Berek, JS. Epithelial ovarian cancer: Risk factors, clinical manifestations, diagnostic evaluation, and staging. In: UpToDate, Basow, DS (Ed), UpToDate, Waltham, MA, 2010.


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