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- Care of the Hospice Patient in the Emergency Department
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ADVANCING EMERGENCY CARE

Lesson 13

Ectopic Pregnancy

Priya Kuppusamy, MD

Objectives

On completion of this lesson, you should be able to:

1. Explain how serum hCG levels correlate with ectopic pregnancy.
2. Describe the role of the discriminatory zone in the evaluation of first-trimester bleeding.
3. List common ultrasound findings indicative of intrauterine pregnancy.
4. Compare the likelihood of heterotopic pregnancy in the general population with the likelihood for those who have used assisted reproductive technology.
5. Describe the emergency department management of an unstable patient with ectopic pregnancy.
6. List the absolute and relative contraindications of methotrexate therapy.
7. Discuss common complications of methotrexate therapy.

From the EM Model

13.0 Obstetrics and Gynecology
13.3 Complications of Pregnancy

Ectopic pregnancy is a life-threatening condition in which a fertilized ovum implants outside of the uterus. If left untreated, it can enlarge and rupture the surrounding tissue, causing massive intraabdominal hemorrhage and death. Although ectopic pregnancy accounts for only 2% of all pregnancies, this diagnosis must not be missed.[1] With higher rates of pelvic inflammatory disease (PID) and increased use of assisted reproductive technologies such as in vitro fertilization, the incidence will continue to rise. This places additional pressure on emergency physicians to confirm or exclude the diagnosis in a timely manner.

Ectopic pregnancy can masquerade as other pathologies such as spontaneous abortion, PID, and certain gastrointestinal disorders, making it difficult to reliably diagnose this condition based on symptoms alone. And although serial serum hCG and ultrasonography have become the cornerstones for evaluation, they come with certain need-to-know caveats and limitations; failing to understand these limitations could result in missing this diagnosis.

The use of medical management with methotrexate has become an accepted alternative to surgical therapy for a stable patient with ectopic pregnancy. Methotrexate comes with its own complications, and emergency physicians must be familiar with these when encountering patients who are undergoing such therapy.

As the options for diagnosis and treatment increase, correct interpretation of data becomes even more important for the effective management of these patients.

Case Presentations

Case One

A 23-year-old woman presents with vaginal bleeding that has been present for the past three days. This morning, she noted passage of a large, solid, clot-like material and intermittent, crampy, abdominal pain. She is unsure about her last menstrual period. Past medical history is significant for a spontaneous abortion two years ago.

On physical examination, the patient's vital signs are blood pressure 100/65, pulse rate 70, respiratory rate 18, temperature 36.7°C (98.1°F), and pulse oximetry 99% on room air. She appears mildly uncomfortable. Her abdomen is soft and nondistended, with diffuse tenderness to palpation in the lower abdomen. There is no guarding or rebound tenderness. On pelvic examination, there is minimal blood. Bimanual examination reveals diffuse tenderness. No cervical motion tenderness or adnexal masses are noted.

A qualitative urine hCG is positive; quantitative serum hCG is 400 mIU/mL. A CBC reveals a hemoglobin of 11 and hematocrit of 33. Her blood type and Rh is O Rh-positive.

On repeat abdominal examination, the patient states that her pain has improved. Her vital signs are stable. She is given instructions on

Critical Decisions

- How do serum hCG levels correlate with ectopic pregnancy?
- What role does the hCG discriminatory zone have in the evaluation of ectopic pregnancy?
- What findings on transvaginal ultrasonography are suggestive of ectopic pregnancy?
- What is the likelihood of heterotopic pregnancy in those using assisted reproductive technology?
- How is an ectopic pregnancy in an unstable patient managed in the emergency department?
- What are the absolute and relative contraindications for methotrexate therapy?
- What are the most common complications of methotrexate treatment for ectopic pregnancy?

threatened spontaneous abortion and discharged home with followup in 48 hours with obstetrics/gynecology (OB/GYN) to obtain a repeat serum hCG level. The patient was advised to expect increased abdominal cramping and vaginal bleeding in the next several days as a result of the progressing spontaneous abortion.

■ Case Two

A 30-year-old woman presents with worsening abdominal pain. She is currently on day three of methotrexate therapy for an ectopic pregnancy located in the right fallopian tube. Serum hCG at the start of therapy was 900 mIU/mL. This morning, she noticed a sharp pain across the lower abdomen that was worse on the right. She denies vaginal bleeding.

On physical examination, the patient's vital signs are blood pressure 110/70, pulse rate 80, respiratory rate 17, temperature of 36.7°C (98.1°F), and pulse oximetry 99% on room air. The patient does not appear to be in any acute distress. Her abdomen is soft and nondistended, with minimal tenderness to palpation in the right lower quadrant. There is no guarding or rebound tenderness. On pelvic examination, no vaginal bleeding is noted. Bimanual examination reveals minimal tenderness to palpation in the right adnexal area.

Serum hCG today is 500 mIU/mL. Her CBC reveals a hemoglobin of 10 and hematocrit of 30. Her blood type and Rh is B Rh-positive.

The OB/GYN is reassured by the patient's decreased serum hCG level. Because abdominal pain is an expected finding after initiating methotrexate therapy and the hematocrit was within the normal range, the OB/GYN is not concerned about a rupture and thinks that ultrasonography is not currently indicated. Based on these recommendations, the patient is discharged home and instructed to see the OB/GYN in four days.

Ectopic pregnancy is a life-threatening condition that results from the implantation of a fertilized ovum outside of the endometrial cavity; the ampulla of the fallopian tube is the most common location. Although it occurs in only 2% of all pregnancies, ruptured ectopic pregnancy is the leading cause of first-trimester morbidity and mortality.

Risk factors include a history of previous ectopic pregnancy and anything that causes structural damage to the fallopian tubes such as PID or previous surgery. PID is the leading cause of ectopic pregnancy. Use of assisted reproductive technology such as in vitro fertilization should be elicited in the history because this increases the risk several-fold. Smoking promotes abnormal implantation by impairing motility. It is thought that increasing age affects myoelectrical activity, which controls tubal motility. Although any type of contraception lowers the overall risk of pregnancy, contraceptive failure from intrauterine devices or tubal ligation increases the risk of ectopic pregnancy.[2]

The presenting symptoms of ectopic pregnancy, especially in a stable patient, can be quite vague. The classic triad of pain, amenorrhea, and vaginal bleeding occurs in only 50% of cases. However, these same symptoms can also be seen with spontaneous abortion or growing intrauterine pregnancy. Abdominal pain in ectopic pregnancy is nonspecific and can be diffuse, bilateral, unilateral, or even contralateral. The nature of the pain can be sharp or crampy. The vaginal bleeding is often mild but can be heavy with clots and resemble spontaneous abortion.[3]

CRITICAL DECISION

How do serum hCG levels correlate with ectopic pregnancy?

With normally progressing intrauterine pregnancies, the hCG level increases at a predictable rate. It should approximately double every 48 hours during the first trimester until values reach 100,000 mIU/mL. At that point, the doubling rate slows down. hCG levels that slowly increase or plateau in the first eight weeks indicate an abnormal pregnancy that is likely due to spontaneous abortion or ectopic pregnancy. A normal increase in hCG, however, does not rule out an abnormality.

A single hCG measurement is not very useful in the diagnosis of ectopic pregnancy; trends are much better. And along these same lines, serum hCG alone cannot confirm or rule out an ectopic pregnancy. Rather, it

should be used in conjunction with a pelvic ultrasound examination. When ectopic pregnancy is a possibility, an ultrasound examination should be obtained regardless of the hCG level. Approximately 50% of women with ectopic pregnancy present with increasing hCG levels, and 50% present with decreasing hCG levels. The rate of change is much slower than would be expected with a viable intrauterine pregnancy or spontaneous abortion.[4]

Another common misconception is that very low or decreasing hCG levels are more likely to be from spontaneous abortion rather than ectopic pregnancy. In fact, it has been found that approximately 40% of ectopic pregnancies have serum hCG values less than 1,000 mIU/mL.[5]

When hCG levels are decreasing, serial hCG measurements should be performed until levels are no longer detectable in the serum. This can take up to six weeks. Women in whom an intrauterine gestation has not been confirmed remain at risk for rupture of an ectopic pregnancy until there is no detectable hCG. If at any point, the hCG levels start to increase, repeat ultrasonography should be performed.

CRITICAL DECISION

What role does the hCG discriminatory zone have in the evaluation of ectopic pregnancy?

The discriminatory zone is the level of hCG above which a single intrauterine pregnancy should consistently be visible on ultrasonography. The threshold for transvaginal ultrasonography is 1,500 to 2,000 mIU/mL. For transabdominal ultrasonography, the threshold is 3,000 mIU/mL.[6]

If the hCG level is above this threshold and an intrauterine pregnancy is not visualized, the diagnosis is ectopic pregnancy until proved otherwise. If the hCG is below 1,500 mIU/mL and an intrauterine pregnancy is not visualized, the results are indeterminant and ectopic pregnancy cannot be safely excluded.[7] In this particular case, keep in mind that the ultrasound may just not be sensitive enough to detect early evidence of pregnancy when the hCG falls below the discriminatory zone. If the patient is otherwise stable and amenable to followup, arrangements should be made for the patient to follow up with OB/GYN in 48 hours for repeat hCG levels and ultrasound examination.[8]

A common misconception is that transvaginal ultrasonography performed in the setting of a serum hCG below 1,000 mIU/mL is unlikely to reveal any useful information in ruling out ectopic pregnancy. Although the use of the discriminatory zone threshold is helpful in assessing the likelihood of visualization of an intrauterine pregnancy, it has no relevance to the ability to detect ectopic pregnancy using ultrasonography. In one study, 39% of ectopic pregnancies with hCG below 1,000 mIU/mL were, in fact, detectable with ultrasound.[9] The purpose of the discriminatory zone is to aid in the interpretation of sonographic findings within the context of hCG levels. It should not be used to determine whether or not to perform an ultrasound study in the first place. In fact, every evaluation for ectopic pregnancy should include an ultrasound study, regardless of where the hCG falls in relation to the discriminatory zone.[10]

CRITICAL DECISION

What findings on transvaginal ultrasonography are suggestive of ectopic pregnancy?

The absence of intrauterine pregnancy or the presence of an extrauterine mass on ultrasonography suggests ectopic pregnancy. The earliest finding of pregnancy is the double decidual sac sign. It consists of two bright, concentric rings that represent the decidua capsularis (lining the gestational sac) and decidua parietalis (lining the uterine cavity). This can be visualized approximately 4.5 to 5 weeks after the last menstrual period. Although visualizing the double decidua can be helpful, the key lies in the yolk sac, which has a 100% positive predictive value for an intrauterine pregnancy (Figure 1).[11] This structure can be identified at 5 to 6 weeks. An ectopic pregnancy cannot be excluded until a yolk sac is demonstrated within the gestational sac. A fetal pole and cardiac activity can be seen by 6 to 7 weeks.[12]

The pouch of Douglas and abdominal cavity should be assessed for free fluid, which can indicate rupture in the setting of ectopic pregnancy. Keep in mind that blood can accumulate in the pouch of Douglas during menses or spontaneous abortion and a ruptured corpus luteum cyst can cause hemoperitoneum.[13]

Most patients do not have definitive evidence of an ectopic pregnancy on ultrasonography. The likelihood of finding an extrauterine embryo is quite low even in cases of known ectopic pregnancy.

CRITICAL DECISION

What is the likelihood of heterotopic pregnancy in those using assisted reproductive technology?

Heterotopic pregnancy occurs when an extrauterine and intrauterine gestation occur simultaneously.[14] The risk of heterotopic pregnancy increases with assisted reproductive technology, from 1 case per 30,000 women in the general population to 1 case per 100 women who have undergone in vitro fertilization.[15] Given the rarity of heterotopic pregnancy, if an intrauterine pregnancy is visualized in the general population, a concurrent ectopic pregnancy is statistically unlikely. However, if the patient has received fertility treatments, heterotopic pregnancy must be considered.

Management and Treatment

If left untreated, ectopic pregnancy can either regress spontaneously or progress to tubal abortion and rupture. Although the incidence of

spontaneous resolution is unknown, the risk of tubal rupture is the main reason that this diagnosis is managed with high vigilance. With tubal abortion, the products of conception are expelled through the fimbria of the ovary. This allows for the possibility of resorption or reimplantation to the extrauterine structures within the abdominal cavity.[16,17] Both tubal abortion and tubal rupture can result in profound intraabdominal hemorrhage that is rapidly fatal without immediate surgical intervention.

Although surgical intervention is considered the mainstay of treatment for ectopic pregnancy, earlier diagnosis through advances in ultrasonography has made medical therapy with methotrexate an option in unruptured cases.[18] Methotrexate is an antifolate medication that inhibits cell division by interfering with DNA replication. The optimal candidates for treatment with methotrexate are those who are hemodynamically stable, have a serum hCG level less than 5,000 mIU/mL, have no fetal cardiac activity, and will likely be compliant with followup.[19] Although the decision to initiate methotrexate therapy should be made by the OB/GYN consulting service, it is useful for emergency physicians to understand the selection guidelines in order to risk stratify patients who present with abdominal pain after starting treatment.

CRITICAL DECISION

How is an ectopic pregnancy in an unstable patient managed in the emergency department?

Patients with ruptured ectopic pregnancy often present with signs of shock from significant hemoperitoneum. On physical examination, they may have abdominal rigidity, distension, guarding, or rebound tenderness. They can also present with shoulder pain as a result of phrenic nerve irritation when blood contacts the diaphragmatic surfaces.

Emergency physicians should weigh all risks and benefits before transporting an unstable patient out of the emergency department for imaging studies. If ultrasonography is necessary, a bedside study should be attempted. Hemodynamically unstable patients with a positive pregnancy test are assumed to have an ectopic pregnancy until proved otherwise. They need surgical exploration and stabilization.

The emergency department management of these patients consists of fluid and blood resuscitation, prompt OB/GYN consultation, and pain control. In addition, 50 mcg of anti-D immunoglobulin should be administered to any Rh-negative woman in cases of vaginal bleeding or suspected ectopic pregnancy, to help prevent alloimmunization of the mother.

CRITICAL DECISION

What are the absolute and relative contraindications for methotrexate therapy?

Because medical management with methotrexate for ectopic pregnancy is becoming increasingly common, it becomes imperative for emergency physicians to understand the absolute and relative contraindications of this form of therapy.

Patients who are being considered for methotrexate treatment should be hemodynamically stable with an unruptured ectopic pregnancy, be reliable and compliant with followup, and have no medical contraindications such as blood dyscrasias or active gastrointestinal or respiratory disease. Methotrexate is excreted renally and associated with hepatotoxicity, so it should not be given to patients with renal or liver disease. Breastfeeding is also a contraindication because methotrexate can be passed into breast milk.[20]

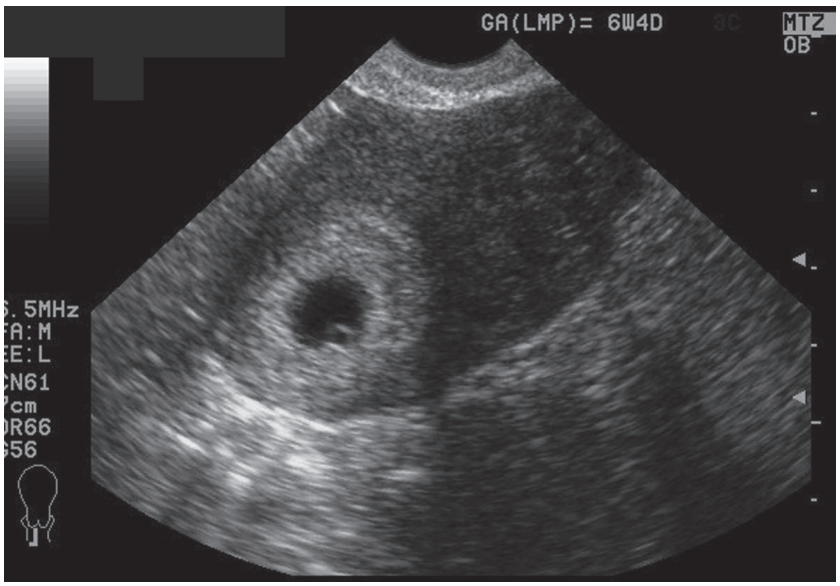
Relative contraindications serve as predictors of failure of methotrexate therapy. These include hCG levels greater than 5,000 mIU/mL, presence of fetal cardiac activity, and ectopic mass greater than 3.5 to 4 cm.[21]

CRITICAL DECISION

What are the most common complications of methotrexate treatment for ectopic pregnancy?

Abdominal pain is the most common complication in women who are undergoing methotrexate

Figure 1.
Intrauterine pregnancy showing gestational sac, yolk sac, and double decidual rings. Image courtesy of Sam Hsu, MD, RDMS.



treatment, and tubal rupture is the most life threatening. According to one randomized clinical trial comparing medical versus surgical treatment, 14% of patients treated with methotrexate developed persistent bleeding and/or rupture.[22]

During medical treatment, most patients experience at least one episode of increased abdominal pain, which usually occurs two to three days after initiation of therapy. Increased abdominal pain is believed to be caused by a tubal abortion, which is the separation of the pregnancy from the site of implantation. This results from the cytotoxic effects of the medication on the trophoblast. The pain itself is mild and resolves 24 to 48 hours after onset. There should be no accompanying signs of hemodynamic instability or acute abdomen.

Unfortunately, the abdominal pain from tubal rupture can mimic the pain associated with the normal progression of methotrexate therapy. With rupture, the pain can be mild and intermittent. The patient may not initially present with hemodynamic instability or acute abdomen. If left untreated, tubal rupture can progress to hypovolemic shock and death from internal hemorrhage. Given the difficulty and risk in differentiating between separation pain and rupture based on symptoms alone, any pregnant patient receiving methotrexate who presents to an emergency department with abdominal pain should be promptly evaluated with a quantitative hCG level and ultrasonography.

Other treatment effects of methotrexate include vaginal bleeding and an increase in hCG levels during the first few days after initiation. The patient may experience adverse effects such as nausea, vomiting, diarrhea, flatulence, bloating, stomatitis, and dizziness. Excessive flatulence and bloating are most common. A small, transient elevation of liver enzymes can also occur but rarely exceeds twice the upper limit of normal.[23]

Studies show that around 56% of women receiving methotrexate will have an asymptomatic increase in the size of the ectopic pregnancy, likely due to hematoma formation. This may persist for a long time, even after hCG levels have become undetectable, but should eventually resolve on its own. The presence of a hematoma should not be interpreted as a treatment failure as long as the trophoblastic tissue itself is decreasing in size.[23]

Another common complication of methotrexate therapy for ectopic pregnancy is failure of treatment. Typically, methotrexate is administered on day one, and an hCG level is checked on day seven. If this value has not declined by at least 25% from day one, a second dose is usually given and the protocol is repeated. Rapidly increasing hCG concentrations after at least two doses of methotrexate can also suggest treatment failure.[23]

Pearls

- Shoulder pain can be a sign of rupture.
- hCG levels alone are inadequate in the evaluation for ectopic pregnancy; always obtain an ultrasound examination.
- Ruptured ectopic pregnancy can present with very low hCG levels.
- The presence of a yolk sac is required for confirmation of intrauterine pregnancy.
- When the hCG level is above the discriminatory zone, an intrauterine pregnancy should be visible on ultrasonography.
- Ultrasonography can still provide useful information in symptomatic patients whose hCG levels are below the 1,500 mIU/mL hCG cutoff.
- Discharged patients should be given verbal and written information on ectopic pregnancy precautions and have access to followup care.

Pitfalls

- Not inquiring about use of assisted reproductive technologies when obtaining history.
- Failing to consider heterotopic pregnancy in patients on fertility treatments.
- Assuming that appropriately increasing hCG levels during the first trimester rules out any abnormality.
- Assuming that very low or decreasing hCG levels are due to spontaneous abortion rather than ectopic pregnancy.
- Not performing ultrasonography because the serum hCG falls below the discriminatory zone threshold.
- Failing to consider rupture in a symptomatic patient receiving methotrexate therapy for ectopic pregnancy.
- Failing to administer anti-D immunoglobulin in Rh-negative women with ectopic pregnancy.

Case Resolutions

■ Case One

The patient who was diagnosed with threatened spontaneous abortion went home and developed worsening abdominal pain and vaginal bleeding. Approximately 36 hours later, she returned to the emergency department. Her blood pressure was 130/80, and her pulse rate was 85. Pelvic examination

showed a large amount of blood in the vaginal vault and tenderness at the posterior fornix. Serum hCG was 300 mIU/mL (compared to 400 mIU/mL from previous visit). Transvaginal ultrasonography showed an empty uterus, a left ovarian mass, and moderate free fluid within the pouch of Douglas. OB/GYN was consulted, and the patient underwent an emergent laparoscopy and salpingectomy for a ruptured ectopic pregnancy within the left fallopian tube. She had a complete recovery.

■ Case Two

The patient who had been discharged home on methotrexate therapy returned to the emergency department 8 hours later with worsening abdominal pain and vaginal bleeding. She was hypotensive and tachycardic on arrival. Bedside transvaginal ultrasonography showed evidence of moderate free fluid concerning for ruptured ectopic pregnancy. A CBC revealed a hemoglobin of 7 and hematocrit of 21. She was resuscitated with intravenous crystalloid fluids and blood transfusion and taken to surgery for a right salpingectomy. She had an uneventful recovery.

Summary

Ectopic pregnancy is uncommon yet unforgiving if missed. It must be considered in any pregnant woman who presents with first-trimester bleeding or abdominal pain. The risk of heterotopic pregnancy increases several-fold with the use of assisted reproductive technology. Serial hCG levels and ultrasound examinations are essential components of the workup, and hCG levels can increase or decrease with ectopic pregnancy. On ultrasound, a yolk sac must be present within the gestational sac of the uterus in order to definitively identify an intrauterine pregnancy. Methotrexate is often used as medical therapy, but treatment failure and subsequent rupture is a life-threatening complication to watch for.

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The LLSA Literature Review

"The LLSA Literature Review" summarizes articles from ABEM's "2014 Lifelong Learning and Self-Assessment Reading List." These articles are available online in the ACEP LLSA Resource Center (www.acep.org/llsa) and on the ABEM Web site.

Article 3

Patient Perceptions of Computed Tomographic Imaging and Their Understanding of Radiation Risk and Exposure

Reviewed by J. Stephen Bohan, MD, MS, FACEP; Harvard Affiliated Emergency Medicine Residency; Brigham and Women's Hospital

Baumann BM, Chen EH, Mills AM, et al. Patient perceptions of computed tomographic imaging and their understanding of radiation risk and exposure. *Ann Emerg Med.* 2011;58(1):1-7.e2.

This study from a single site in New Jersey surveyed patients with abdominal pain with three goals in mind, as follows:

- To assess patients' confidence level with medical evaluations ranging from history and physical (minimal technology) to one that included history and physical and blood testing and an abdominal-pelvic computed tomography (CT) scan (maximum technology).
- To assess patients' understanding of relative radiation from a CT exposure compared to a two-view chest radiograph or with the statement that "2 to 3 abdominal CTs give the same radiation exposure as experienced by Hiroshima survivors."
- To assess understanding of cancer risk related to CT scans.

There were 1,168 participants. More than 25% had incomes below $10,000 per year.

For the first question, the authors used a visual analog scale. Confidence in the simple history and physical was scored at 20, whereas evaluation with maximum technology was scored at 90.

With respect to knowledge of radiation, 50 participants thought that a chest radiograph had more radiation than a CT and so were confused by the question such that they could not fill out this part of the form. Of the remaining individuals, only small numbers of patients understood the true relationship of either statement, 5% and 13% respectively.

When asked about prior CT, about 38% denied having had a prior CT. However, a review of the electronic record demonstrated that about a third of these patients had had at least one prior CT within the past five years.

Highlights

- People have a misplaced faith in technology, particularly images.
- People largely underestimate the radiation received from a single CT.
- People's recollections of prior events related to CT are demonstrably inaccurate, which is no different than their recollections of other types of events.

Lesson 14

Spontaneous Pneumothorax

Nathan L. Tranchell, DO, and Jno Disch, MD

Objectives

On completion of this lesson, you should be able to:

1. Describe physical signs and symptoms related to spontaneous pneumothorax.
2. State both common and several reported risk factors for developing spontaneous pneumothorax.
3. Discuss the management and treatment options available for patients with spontaneous pneumothorax.
4. Explain the imaging modalities available for diagnosis of spontaneous pneumothorax.
5. Discuss pitfalls in the diagnosis and management of spontaneous pneumothorax.
6. State several complications of spontaneous pneumothorax.

From the EM Model

16.0 Thoracic-Respiratory Disorders

16.2 Disorders of Pleura, Mediastinum, and Chest Wall

Spontaneous pneumothorax is defined as the accumulation of air in the pleural space, with subsequent lung collapse, occurring without a precipitating event. The entity is further divided into primary (no underlying lung disease) and secondary (underlying lung disease) spontaneous pneumothorax. Pleural blebs/bullae have long been thought to represent the dominant etiology in spontaneous pneumothorax formation. Smokers and tall, lean, young men are at higher risk for primary spontaneous pneumothorax. The risk of secondary spontaneous pneumothorax is thought to be related to chronic obstructive pulmonary disease (COPD) primarily, but also to cystic fibrosis, HIV-associated *Pneumocystis jiroveci* pneumonia, tuberculosis, and lung cancer.

The most common presenting complaint in patients with pneumothorax is ipsilateral chest pain. The pain is described as having an acute onset and occurring at rest; it usually resolves within 24 hours despite the persistence of the pneumothorax. Physical examination can reveal decreased breath sounds, hyper-resonance to percussion, and decreased tactile fremitus on palpation. Hypotension, tachypnea, tachycardia, and cyanosis should raise concern for possible tension pneumothorax, a rare complication of primary spontaneous pneumothorax. Clinically, the patient might appear surprisingly healthy or acutely ill.

There is some debate over the best way to diagnose and treat spontaneous pneumothorax. In general, if the diagnosis is suspected, the patient should have an upright, full inspiratory, posteroanterior chest radiograph. If the posteroanterior radiograph is normal and clinical suspicion is high, a lateral decubitus radiograph should be obtained. Treatment options vary greatly, from observation to needle decompression, intercostal tube drainage, and surgical interventions, and should be tailored to the patient's clinical presentation.

Case Presentations

Case One

A 24-year-old man presents with sudden onset of chest pain. His pain is right-sided and described as sharp, nonradiating, and focal. Onset was 18 hours ago while the patient was sitting at his desk studying for an examination. He reports shortness of breath that was worse initially but is still present. He does not notice any association with respirations or exertion. The patient denies any recent respiratory illness or symptoms. He has been afebrile. His past medical and surgical histories are negative except for tonsillectomy as a child. The patient takes no medication and has no drug allergies. While discussing his social history, he tells you that he lives in the dorms at the local university and is planning on becoming a pilot; he smokes one half pack of cigarettes a day, does not use alcohol, and drinks several cups of coffee a day.

Vital signs are blood pressure 127/82, pulse rate 88, respiratory

Critical Decisions

- Does size of the pneumothorax matter when selecting a treatment modality?
- What percentage of spontaneous pneumothorax will recur despite treatment?
- Which patients with spontaneous pneumothorax can be safely discharged home?
- What activity restrictions are advisable for a patient with spontaneous pneumothorax?
- Is air transport safe for a patient with significant pneumothorax?

rate 18, temperature 37°C (98.6°F), and oxygen saturation 95% on room air. The patient is 6 feet, 3 inches tall and weighs 178 pounds. A screening ECG shows normal sinus rhythm at 89 beats per minute without ectopy; the measurable intervals are within normal limits, as are the noted waveforms. Auscultation of the lungs reveals bilateral breath sounds. On further focused physical examination, no palpable crepitation, fremitus, or hyper-resonance to percussion is elicited. The heart examination reveals a regular rate and rhythm without murmurs, rubs, or gallops.

Posteroanterior upright chest radiograph reveals a small pleural line with decreased lung markings peripherally. You diagnose the patient with a small- to moderate-sized right-sided spontaneous pneumothorax.

■ Case Two

A 28-year-old woman presents because she has been short of breath and had left-sided chest pain for the past two days, and it seems to be getting worse. Her symptoms are worse with inspiration and only moderately relieved with rest. She was driving when she had the sudden feeling of dyspnea and a stabbing sensation just superior and lateral to the left breast. She appears very anxious and is hyperventilating. Further review finds a healthy 28-year-old woman; she does not smoke or drink. She has no prior medical or surgical history. She denies being sexually active and is not on birth control; her last menstrual cycle started two days ago. Family history is negative for clotting disorders, arrhythmia, or sudden cardiac death.

The emergency physician begins the patient's evaluation while awaiting vital signs. Her airway is intact as she is answering questions. Breath sounds seem decreased on the left; she has some mild tactile fremitus, and although it is difficult to ascertain in the loud emergency department environment she seems to have hyper-resonance to percussion. The trachea is midline. The patient appears tachypneic and is mildly tachycardic with an auscultated pulse of 108 without other abnormalities on cardiac examination. Vital signs are obtained and are blood pressure 102/68, heart rate 106, respiratory rate 30, temperature 37°C (98.6°F), and oxygen saturation 98% on room air. A stat portable upright chest radiograph is obtained and shows a large left-sided pneumothorax.

Epidemiology

Primary spontaneous pneumothorax occurs in approximately 7.4 to 28/100,000 men per year and in 1.6 to 6/100,000 women per year.[1-3] This results in over 20,000 patient visits per year and $130,000,000 in healthcare costs.[1] Approximately one-third of all cases of spontaneous pneumothorax are secondary pneumothorax, with COPD accounting for nearly 70% of the underlying lung disease in those cases.[4,5] Primary spontaneous pneumothorax is well described to occur generally in tall, thin boys and men within an age range of 10 to 30 years; it is very rare in individuals over 40 years of age. Secondary spontaneous pneumothorax is more common in older individuals with a history of COPD such as emphysema. Reportedly only 0.8% of patients with emphysema and 0.3% of patients with asthma who are hospitalized develop spontaneous pneumothorax.[4]

Primary spontaneous pneumothorax recurs in 20% to 60% of individuals, with contralateral recurrence estimated at between 16% and 57%.[2,5-9] Recurrence rates are higher in patients with secondary spontaneous pneumothorax and are estimated at between 40% and 80%.[10] Recurrence rates less than 5% have been reported after more definitive surgical treatment.[2,7,11] Recurrence usually takes place during the first year and a half to two years after the initial diagnosis.[6,8]

Many authors agree that smoking significantly increases the risk of both primary and secondary spontaneous pneumothorax.[3,7-9] Taller men with low body mass index tend to be at higher risk for spontaneous pneumothorax as well as for recurrence of pneumothorax.[3,6,12] Most patients with primary spontaneous pneumothorax, however, will not have a repeat pneumothorax, and recurrence prevention should be held until after the first episode of recurrence.

Mortality rates calculated from British studies are reported at 1.26 per 1,000,000 for men and 0.62 per 1,000,000 for women, which is less than 1% of those hospitalized with spontaneous pneumothorax.[3,6,9]

Etiology

Subpleural blebs have long been considered the major factor contributing to primary spontaneous pneumothorax. Blebs have been found in up to 90% of cases at

thoracoscopy and in up to 80% on CT scan of the thorax.[3,13] It is theorized that the higher distending pressure at the apex of the lung compared with the lung bases in taller individuals may predispose them to bleb/bulla formation.[3,5,7] Other possible causes of bleb formation include malnutrition, connective tissue disorders, local ischemia, and inflammation of the distal airways.[13] Low body mass index is also described as a risk factor for developing primary spontaneous pneumothorax. Another factor that might be associated with development of primary spontaneous pneumothorax is that of "pleural porosity," which describes air leakage from areas of disrupted mesothelial cells replaced by an inflammatory elastofibrotic layer that is more porous and allows for air seepage.[7-9,13] Smoking has also long been associated with development of the condition. The lifetime risk of developing pneumothorax could be increased from 0.1% in nonsmokers to 12% in smokers. This increases the incidence 9-fold in women and up to 22-fold in men.[7,14,15] Pneumothorax development secondary to smoking may be a result of bronchiolar inflammation leading to trapping of air distally and overdistension.[7] One precipitating event might be a change in atmospheric pressure, which could explain the clustering of events that has sometimes been observed.[10,12] There appears to be no relationship between spontaneous pneumothorax and exercise; in the absence of trauma it usually occurs at rest.[3,8] There is no need to instruct patients to avoid exercise to prevent recurrence.

Secondary spontaneous pneumothorax has been associated with nearly every lung disorder. About 2% to 6% of patients with AIDS will experience pneumothorax, generally with concomitant *P. jiroveci* pneumonia.[4,10] If malignancy is found, it could suggest underlying lung metastases. The leading cause of secondary spontaneous pneumothorax in developing countries is tuberculosis and lung abscess.[4] In 8% to 20% of patients with cystic fibrosis, spontaneous pneumothorax will occur at some point in their lives.[10,16] Catamenial pneumothorax or thoracic endometrial syndrome usually occurs within one to three days of the onset of menses. It is likely due to heterotopic endometriotic tissue abnormalities found on the diaphragm and sometimes lung.[17] This entity, although fairly rare, may be more common than first thought. Because of the high recurrence rates of catamenial pneumothorax, prevention measures should be initiated after the first episode, and resection of the diaphragm as well as endometrial lesions found in the lung is required.[10,17] Dozens of other rare etiologies for pneumothorax have been described, including lymphangioleiomyomatosis, histiocytosis X, alpha-1 antitrypsin deficiency, chemotherapy, pulmonary embolism, hydatid cyst rupture, Birt-Hogg-Dubé syndrome, Marfan syndrome, coughing, laughing, listening to loud music, abusing cocaine, high winds, and many others.

Pathophysiology

Normal intrapleural pressure is negative compared to atmospheric pressure, ranging from –12 mm Hg on inspiration to –4 mm Hg on expiration.[4] Elasticity of the chest wall and alveoli allows the chest wall to spring out and the alveoli to recoil in; these two forces help produce this negative pressure.[5] Intrapleural pressure becomes even more sub-atmospheric with the aid of respiratory musculature.[9] Intra-alveolar and bronchial pressures are negative only on inspiration, however, and become positive (+3 mm Hg) on expiration.[4] The pleural space has a small amount of fluid to allow for smooth movement of the visceral and parietal pleura over each other.[5] Defects between the alveolar walls and visceral pleura allow air to escape into the pleural space until the pressures have equalized or the defect has closed, and the lost pressure gradient causes the lung to collapse as air is sucked into this space.[4]

In tension pneumothorax, the defect acts as a one-way valve allowing air into the pleural space during inspiration and trapping it during expiration.[4,10] Once intrapleural pressure exceeds 15 to 20 mm Hg, blood return to the heart can become impaired leading to cardiovascular collapse. As the pressure builds, the ipsilateral lung collapses and the contralateral lung is compressed, leading to worsening asphyxia and hypoxia.[4]

Clinical Presentation

Nearly all patients with pneumothorax have chest pain that is usually of sudden onset, occurs at rest, and resolves within roughly 24 hours. The pain is initially described as pleuritic but evolves to a slow steady ache.[4] Dyspnea may or may not be present and is rarely extreme in primary spontaneous pneumothorax but may be so in secondary spontaneous pneumothorax.[4] Patients with secondary spontaneous pneumothorax generally have more severe symptoms and a more serious clinical presentation than those with primary pneumothorax. They experience breathlessness out of proportion to the size of pneumothorax.[3,5] Symptoms of severe dyspnea, cyanosis, and hemodynamic instability (hypotension, tachycardia, low oxygen saturation) should prompt consideration of tension pneumothorax. The physical examination can reveal hyper-resonance to percussion, decreased tactile fremitus on palpation, decreased breath sounds on auscultation, and decreased chest wall movement on inspection. The most common clinical finding may be a sinus tachycardia caused either by pain or by respiratory/cardiovascular compromise.[4,13]

Diagnosis

Diagnosis is made by chest radiograph demonstrating a thin visceral line with a radiolucent band devoid of lung markings and parallel to the chest wall, with or without an air-fluid level. An upright posteroanterior full inspiratory chest radiograph is the preferred view; lateral decubitus views are also helpful and should be obtained if pneumothorax is suspected and not seen on initial upright chest radiograph. Expiratory radiographs are generally not needed and add no value to the routine diagnosis of pneumothorax.[3,5,10,13] The British Thoracic Society defines a large pneumothorax as one with a 2-cm or larger visible rim around the lung margin and chest wall.[3,5] The American College of Chest Physicians defines a large pneumothorax as one with an apex-to-cupola distance of more than 3 cm, which would be a pleural volume of more than 15% to 20%.[1,3,12] The British method is derived using the Light index, which is a formula for determining the volume of air inside the pleural cavity; more than 2 cm of visible rim would indicate a volume of more than 50%.[3] Noppen has defined a large pneumothorax as "complete dehiscence of the lung from the chest wall" and small pneumothorax as "partial dehiscence."[18] British Thoracic Society guidelines in 1993 defined pneumothorax size as small ("small rim of air around the lung"), moderate ("collapsed halfway towards the heart border"), and large ("airless lung, separate from the diaphragm").[3] On chest radiograph, contralateral shift of the trachea and mediastinum is normal for spontaneous pneumothorax and, because of pleural air entry, it is not diagnostic of tension pneumothorax.[8,10] In secondary spontaneous pneumothorax, a computed tomography (CT) scan can be helpful to differentiate large thin-walled bulla or visualize a small pneumothorax, which may be clinically significant given the underlying lung disease.[5,10,13] A CT scan may also be used to detect contralateral blebs/bullae, which may require treatment for recurrence prevention.[13] More than half of patients with spontaneous pneumothorax have contralateral blebs or bulla, and around 25% will develop contralateral pneumothorax at some point.[13]

Management and Treatment

The treatment goals for spontaneous pneumothorax are to remove air from the pleural space and to prevent recurrence. Small spontaneous pneumothorax with minimal or no symptoms may be treated with observation alone.[3,12] Initial management of symptomatic spontaneous pneumothorax may include either high-flow supplemental oxygen (10 L/min), simple aspiration, or intercostal tube drainage. Air absorption in stable pneumothorax occurs at approximately 1.25% to 1.8% per day without intervention.[5,12] High-flow supplemental oxygen increases the nitrogen gradient between the pleural and alveolar space, which is the driving force behind pneumothorax reabsorption and increases air absorption rates by a factor of four.[5,10,15,19] One study reports a success rate of 79% for resolution of primary spontaneous pneumothorax solely with observation; this includes small, moderate, and large pneumothorax.[20]

Compared to primary spontaneous pneumothorax, which is often viewed as somewhat of a nuisance, secondary spontaneous pneumothorax often represents a potentially life-threatening event because of the patient's underlying lung disease.[10]

CRITICAL DECISION

Does size of the pneumothorax matter when selecting a treatment modality?

Some authors think that treatment should be based on size, and others think that treatment should be based on symptoms and clinical presentation. Any clinically unstable patient with pneumothorax, regardless of its size, should be treated with intercostal drainage, as should patients with large, clinically stable pneumothorax. Treatment of small and nonsymptomatic moderate-to-large pneumothorax seems to fall within a grey area. The British Thoracic Society recommends needle aspiration and 6 hours of observation with discharge home if the patient is stable, and many authors agree with this approach. The American College of Chest Physicians guidelines recommend 3 to 6 hours of observation but rarely advocate needle aspiration.

Patients with secondary spontaneous pneumothorax who have been treated with simple aspiration should be observed for at least 24 hours, as this procedure is less likely to succeed in these patients. Simple aspiration is performed either with a 16- or an 18-gauge cannula and three-way tap inserted in the midclavicular line of the second intercostal space and removed with full evacuation of air, or via a small-bore catheter (<14F) inserted using the Seldinger technique at the same location.[3,10] Success rates of the procedure are reported at between 58% and 80%.[5] Patients to be discharged after simple aspiration or observation should have a chest radiograph performed at 6 hours after the initial study; they should also have a 24- to 48-hour followup chest radiograph.[1,5,13] Simple aspiration has been shown to make no significant differences in one-year recurrence, initial failure rate, and early success rate. It has been associated with a shortened hospital length of stay, decreased number of days lost from work, and lower admission rates.[3,13,15,21]

Large spontaneous pneumothorax should be treated with intercostal tube placement or small-bore catheter drainage (<14F).[1,10] For intercostal drainage, small chest tubes (16F to 22F) are initially recommended by the American College of Chest Physicians and should be attached to a water seal or Heimlich valve.[1,3,22]

Unstable patients, those with suspected bronchopleural fistula, or those on mechanical ventilation should have a larger (24F to 28F) tube placed initially.[1,22] There is no strong data to suggest prophylactic antibiotics need to be given in nontraumatic pneumothorax after chest tube placement.[22] Persistent air leak after more than 24 hours or failure of the lung to reexpand may require the addition of low intermittent suction (–10 to –20 cm H_2O).[1,3] Further failure of lung reexpansion at this point can require more aggressive intervention. Surgical intervention is recommended in cases of recurrent ipsilateral pneumothorax, contralateral pneumothorax, bilateral spontaneous pneumothorax, persistent air leak (>5 to 7 days), failure of lung reexpansion, spontaneous hemothorax, and tension pneumothorax and in those with at-risk professions (ie, pilots, divers).[3,5,7,12] Pleurodesis with talc or other sclerosing agents can be performed both medically (through the chest tube) or surgically.[17] Other surgical options include electrocautery of the visceral pleura, mesh covering technique, thoracotomy with bullectomy and pleurectomy, and bleb resection via numerous methods.[5,12,17]

Recurrence rates are 20% to 60% with simple conservative treatment and improve to less than 5% after surgical pleurodesis. This procedure may be warranted when multiple abnormalities are noted on the radiograph at the time of diagnosis.[2]

Complications

Complications of spontaneous pneumothorax result from both the disease itself and the treatment. Nearly half of all patients wait more than two days after initial symptom onset to seek medical attention, which can increase the risk of reexpansion pulmonary edema.[3,4] Reexpansion pulmonary edema is a rare but serious complication of treatment thought to be associated with young age, large and persistent pneumothorax, longer time from development to treatment, and rapid reexpansion.[13] No matter the cause of pneumothorax, tension pneumothorax is a serious potential complication. This is a true emergency, and diagnosis should be made clinically and not by radiography because circulatory or respiratory failure may ensue. Spontaneous hemopneumothorax is found in 0.5% to 2.6% of patients with spontaneous pneumothorax and is defined as more than 400 mL of air and blood within the pleural cavity.[13] Pneumomediastinum and subcutaneous emphysema have been reported to occur with spontaneous pneumothorax and are thought to be associated with exertional maneuvers such as Valsalva.[4,23] Other complications are related to risks associated with surgery and anesthesia as well as violation of the body's skin barrier during needle aspiration and intercostal tube placement (ie, infection, bleeding, scarring). With intercostal tube placement, inadvertent injury to organs such as the stomach, spleen, lung, liver, heart, and great vessels could be fatal.[3] Acute respiratory distress syndrome and empyema are both rare complications of treatment.[3]

CRITICAL DECISION

What percentage of spontaneous pneumothorax will recur despite treatment?

Recurrence rates after an initial episode of pneumothorax treated via methods not aimed at preventing recurrence are reported to be between 16% and 60%, with the average around 30%. Most of these events occur within two years of the initial pneumothorax.[2,6,7,12] Recurrence rates after a second spontaneous pneumothorax increase to around 63%, and to roughly 83% after a third.[6,12] Contralateral recurrence has been reported to occur to 18% to 50% of patients.[7] Recurrence rates following surgical management range between 4% and 20%.[2] One study reported recurrence rates of 36% in a simple drainage group, 13% in a tetracycline pleurodesis group, and 8% in a talc pleurodesis group.[6] It still remains that most patients (50% to 70%) will not have a second pneumothorax after noninvasive treatment, and preventive treatments should be reserved until after the first recurrence. Patients should be made aware of this risk.

Disposition

Disposition of a patient with a spontaneous pneumothorax requires careful consideration given the potentially serious outcomes possible with this condition (Table 1). Patients with small pneumothorax generally do not require simple aspiration or intercostal drainage and may be appropriate for outpatient observation level of care for evaluation of size and symptoms.[1] These patients can be evaluated and managed in the emergency department observation unit on high-flow oxygen. Patients in this group may be discharged home after 6 hours of observation if repeat chest radiograph shows no progression of the pneumothorax.[1,3,10] There is much debate concerning who can be discharged after short emergency department observation and who should be admitted to the hospital. Those who live far from

Table 1.
Emergency department disposition of pneumothorax patient

Type of pneumothorax	Patient disposition
Small primary spontaneous pneumothorax	Consider outpatient observation
Moderate-to-large primary spontaneous pneumothorax	Inpatient admission
Secondary pneumothorax	Inpatient admission

emergency services or have unreliable followup care should be admitted.[1] No matter the size of pneumothorax, any patient requiring air transport should have a chest tube in place prior to flight. All patients with secondary pneumothorax should be admitted and observed because they have higher risks of complications and initial treatment failure.[1,3]

CRITICAL DECISION

Which patients with spontaneous pneumothorax can be safely discharged home?

The American College of Chest Physicians guidelines suggest that those who are clinically stable and who have a small pneumothorax may be discharged after 3 to 6 hours of observation if a repeat radiograph shows no progression of the pneumothorax. The British Thoracic Society recommends 6 hours of observation. There are many published reports of patients with small primary spontaneous pneumothorax being safely discharged home after conservative treatment with high-flow supplemental oxygen with or without needle aspiration. Any patient discharged from the emergency department should have repeat chest radiographs at 3 to 6 hours and 24 to 48 hours after presentation to ensure proper resolution.

Those with secondary spontaneous pneumothorax and large pneumothorax should rarely be discharged from the emergency department as they are at greater risk of complications and failure of initial treatment. All patients with secondary spontaneous pneumothorax should be admitted because the mortality rate is about 10% even after resolution of pneumothorax.[3]

CRITICAL DECISION

What activity restrictions are advisable for a patient with spontaneous pneumothorax?

Physical activity is not reported to be a risk factor for the development of pneumothorax. After discharge, patients may return to normal activity with few restrictions after the pneumothorax has resolved.

Two common activities that need to be addressed are flying and diving. Flying has not proved to be a risk factor for spontaneous pneumothorax even though, theoretically, the repetitive changes in ambient pressure would put one at risk. Patients should be able to travel safely on commercial aircraft once there is complete resolution of pneumothorax, usually in 3 to 6 weeks; however, both the United States military and international flight regulations require recurrence prevention in all aviation personnel post primary spontaneous pneumothorax.[10] US safety regulations recommend a 3-week waiting period prior to air travel, while the British Thoracic Society recommends a 6-week waiting period after surgery or resolution on radiograph.[3,10] There is no evidence to suggest that air travel causes recurrence; however, in-flight recurrence would have serious repercussions.[3] Patients should be aware that increased risk of recurrence is present for 1 to 2 years after the initial incident and has been reported even later.

A history of primary spontaneous pneumothorax is a contraindication to diving because air in the lungs will expand during ascent in accordance with the Boyle law.[10] Even with documented bullae, blebs, or emphysema without the presence of pneumothorax, diving is not permitted because life-threatening complications can occur.[10] In some cases, diving may be permitted after definitive prevention of recurrence via surgical pleurectomy has been performed as per the British Thoracic Society guideline.[3]

CRITICAL DECISION

Is air transport safe for a patient with significant pneumothorax?

Air transport of a patient with pneumothorax is safe; however, there must be an open connection between the pleural space and the ambient atmospheric pressures.[10] Any time a patient with a pneumothorax is transported, an intercostal tube drain attached to either a water seal or Heimlich valve should be in place. Complications such as tension pneumothorax and cardiovascular collapse during any transport could be catastrophic, and this is especially true when flying.

Case Resolutions

■ Case One

This patient is a tall young man who smokes, which puts him at risk for primary spontaneous pneumothorax; being a pilot might, in theory, increases his risk, although this has not been proved.[10] The physician discussed treatment options with the patient, who elected simple aspiration instead of intercostal tube drainage. A 16F needle was inserted at the second intercostal space in the midclavicular line and air was withdrawn. The cannula was then attached to a three-way valve system to allow for further air removal. The patient was placed on supplemental oxygen at 10 L/min. He reported complete resolution of his symptoms. Vital signs remained stable. A chest radiograph, obtained at 6 hours, showed near complete resolution of the pneumothorax. The patient was told that he could resume his normal daily activities but was instructed to avoid flight for 2 to 3 weeks because ambient pressure changes could cause a recurrence. He was told to return to the emergency department at any time if he experienced any shortness of breath or dyspnea on exertion and to return in 24 hours for a followup chest radiograph and evaluation. He was advised that pneumothorax recurs within 2 years in about 30% of cases.

■ Case Two

The young woman in this case had a significantly symptomatic large pneumothorax. Intercostal drainage was, therefore, the treatment of choice, although needle decompression while preparing for chest tube insertion could have been considered. If treatment had been

delayed, the patient might have developed a tension pneumothorax which, although rare, is life threatening. The patient, however, appeared stable, and a 16F chest tube was inserted at the fourth intercostal space near the midaxillary line and attached to water seal. With insertion of the tube, the patient's respiratory rate decreased to 20 breaths per minute and her heart rate improved to 100 beats per minute. The patient was diagnosed with probable catamenial pneumothorax, which sometimes occurs in young women several days after the onset of menses, and was admitted to the hospital. The thoracic surgery team was consulted both to manage the chest tube on admission and to evaluate for possible surgical intervention because this entity is known to have a very high recurrence rate. This patient had a repeat chest radiograph at 24 hours, and a video-assisted thorascopic surgery procedure was scheduled. The obstetrics and gynecology service was consulted because hormonal suppression therapy is sometimes recommended to prevent further occurrence, although it, along with pleurodesis, have not proved to be very effective.[17]

Summary

Spontaneous pneumothorax is a fairly common disease entity in the emergency department. Presentation and clinical findings can range from merely a nuisance to a life-threatening disorder. Small, minimally symptomatic, primary spontaneous pneumothorax may be treated with supplemental oxygen and observation, and patients may be discharged home with careful followup. All patients with secondary pneumothorax should be admitted but may be treated conservatively initially. Initial treatment with needle decompression is less invasive and has been associated with a shorter hospital stay and fewer days of work lost without an increase in recurrence or failure rates. Nevertheless the American College of Chest Physicians rarely advocates simple needle aspiration. Regardless of initial treatment, the recurrence rate is around 30% after an initial occurrence. Any large or symptomatic pneumothorax requires intercostal tube drainage and admission. Oxygen administration, specifically, high-flow oxygen at approximately 10 L/min, can speed the rate of reabsorption by up to four times. A certain subset of patients will require surgical intervention and should be referred early for proper management. Tension pneumothorax is a rare complication of spontaneous pneumothorax and should be diagnosed clinically with prompt initiation of treatment. Secondary spontaneous pneumothorax has been described in nearly every disorder of the lung but is most commonly seen in COPD.

Pearls

- A patient with a small primary pneumothorax can be safely discharged home after 6 hours of observation if a repeat radiograph shows no increase in the size of the pneumothorax.
- High-flow, 10 L/min, supplemental oxygen can increase the reabsorption rate of intrapleural air by up to four times.
- Nearly every disease that can affect the lung has been associated with pneumothorax; a high clinical suspicion is warranted.
- Physical activity is not a cause of pneumothorax and need not be restricted on discharge.

Pitfalls

- Relying only on initial posteroanterior upright chest radiograph to make the diagnosis of pneumothorax. If the entity is suspected and not visualized on this view, obtain lateral decubitus views. Expiratory films are generally not recommended.
- Discharging home after initial evaluation any patient with secondary spontaneous pneumothorax, regardless of the size of the pneumothorax.
- Failing to specifically warn the patient not to travel by air within the first 2 to 3 weeks after a pneumothorax because this can cause recurrence of the pneumothorax.
- Failing to be alert for tension pneumothorax, a serious but rare complication; diagnosis should be made clinically, not by radiograph.
- Failing to ensure that an intercostal tube is in place when a patient with a pneumothorax of any size and cause is transported by air.

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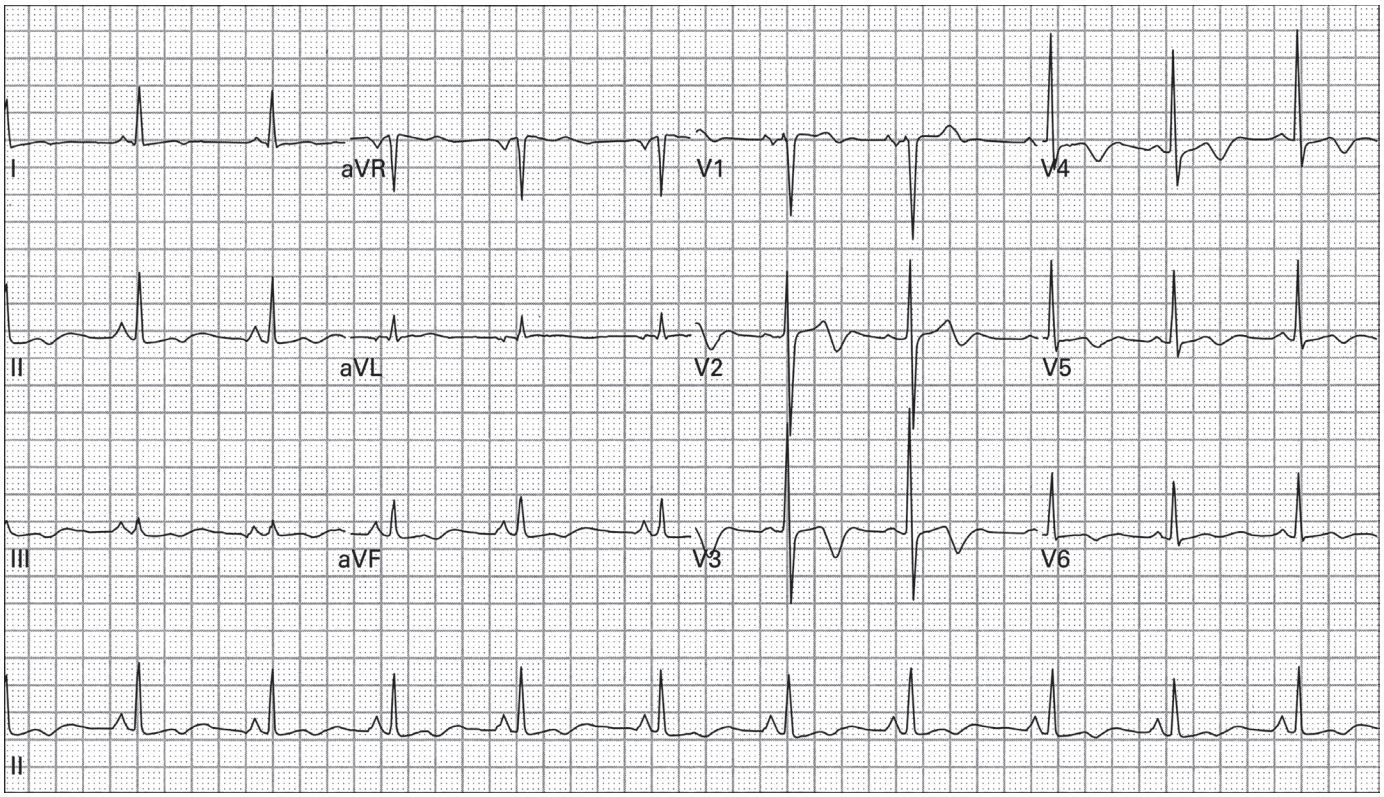
The Critical ECG

A 46-year-old woman with chest pain, upper abdominal pain, and diaphoresis.



Sinus rhythm, rate 64, right atrial enlargement, nonspecific T-wave flattening in the inferior leads, T-wave abnormality in the anterior leads consistent with acute anterior ischemia. The ECG demonstrates Wellens sign—biphasic T waves in the mid-precordial leads. Wellens sign is a highly specific marker of proximal left anterior descending (LAD) coronary artery disease. The T-wave abnormality often occurs even in the absence of chest pain. This patient had emergent coronary angiography, which demonstrated a 90% obstructing proximal LAD lesion. The T-wave abnormality resolved after angioplasty.

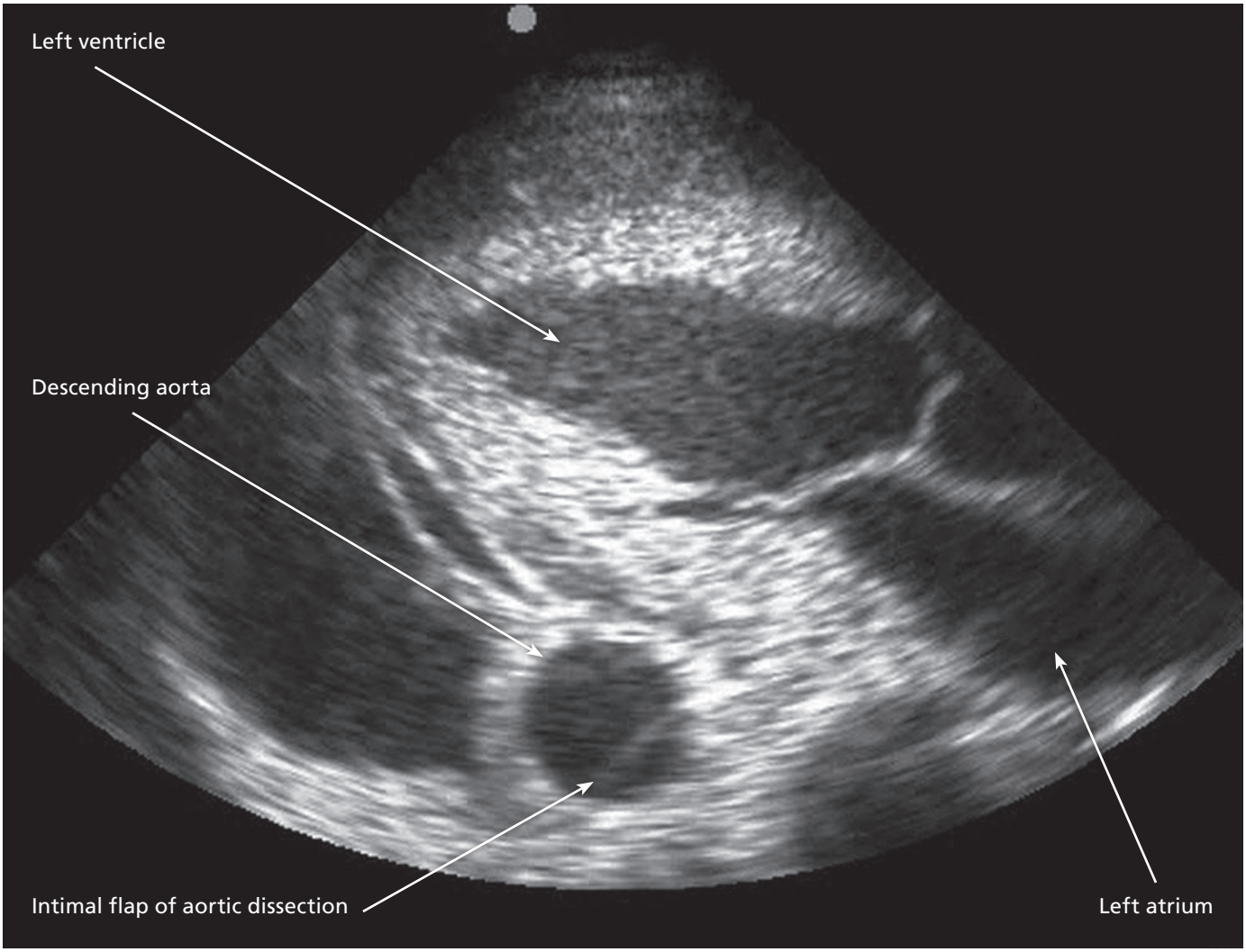
Feature Editor: Amal Mattu, MD, FACEP. From: Mattu A, Brady W. *ECGs for the Emergency Physician.* London: BMJ Publishing; 2003:124,150. Available at www.acep.org/bookstore. Reprinted with permission

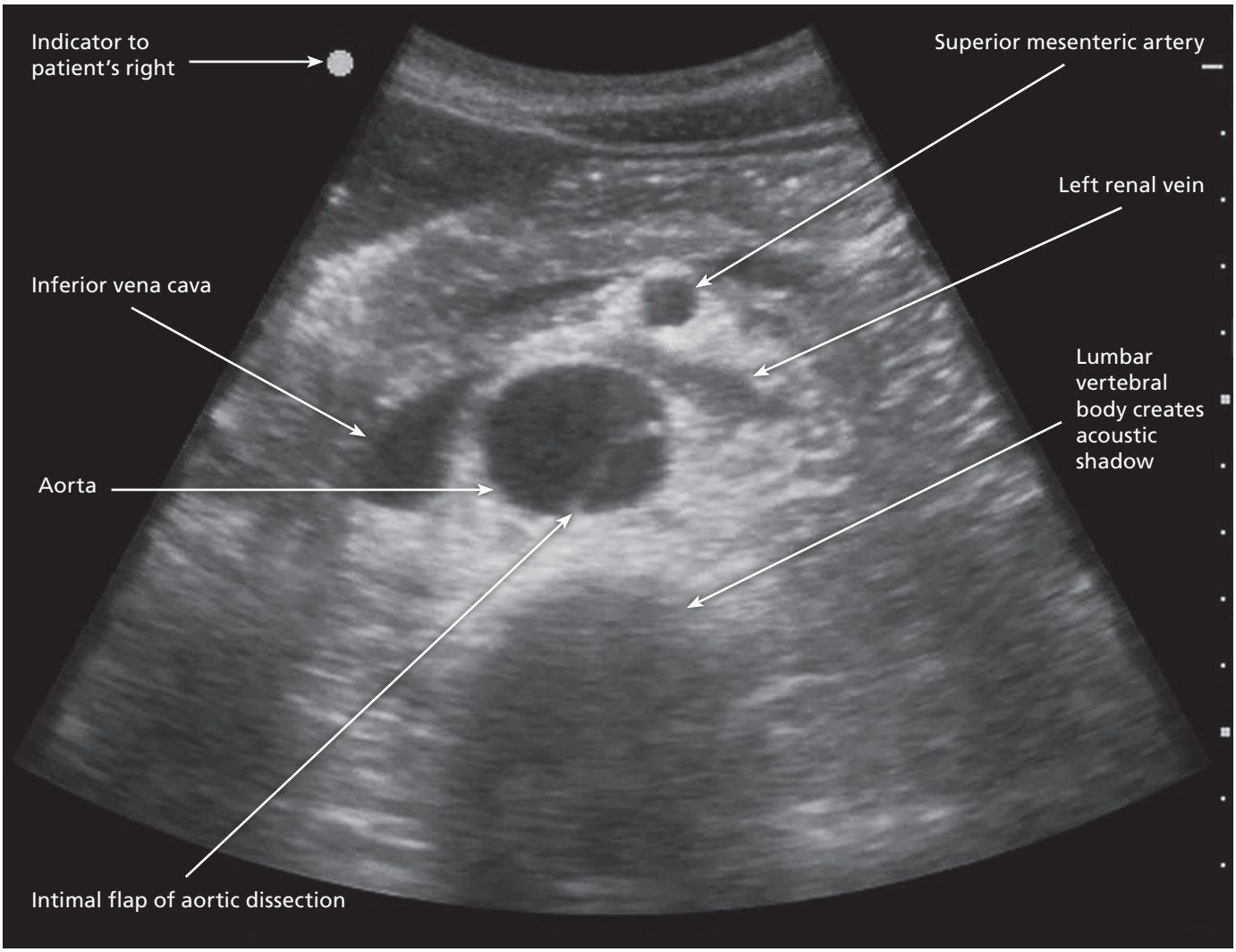
The Critical Image

A 48-year-old man with hypertension, presenting with left scapular pain radiating to his lumbar region. He also notes subjective bilateral lower extremity weakness. The patient had been evaluated four days earlier for similar complaints and treated with ibuprofen and cyclobenzaprine without relief.

His vital signs at triage are blood pressure 188/121, heart rate 121, respiratory rate 18, tympanic temperature 37.2°C (99°F), and oxygen saturation 98% on room air. Examination showed an uncomfortable patient with normal cardiac, pulmonary, abdominal, and extremity neurovascular examination.

Bedside ultrasonography was performed by the emergency physician.





Aortic dissection is defined by disruption of the intimal lining of the aorta. It occurs in patients with a history of hypertension in approximately 70% of cases.[1] Males are affected more than females (65%). The mean age is around 63 years. Back pain occurs in 53% of patients.

Transesophageal echocardiography (TTE) has sensitivity (98%) and specificity (95%) for aortic dissection, similar to CT.[2] Less is known of the sensitivity and specificity of transthoracic and transabdominal ultrasound, particularly in the hands of emergency physicians. The modality should not be used to rule out aortic dissection, but may be used to identify probable dissection early, allowing more rapid treatment and involvement of key consultants.

This patient was immediately treated for aortic dissection with esmolol and nicardipine. Cardiothoracic surgery was called to the bedside, and preparation for possible surgical repair was made. CT angiography was rapidly performed and confirmed type A aortic dissection, which was operatively repaired.

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Feature Editor: Joshua S. Broder, MD, FACEP. See also *Diagnostic Imaging for the Emergency Physician* (winner of the 2011 Prose Award in Clinical Medicine, the American Publishers Award for Professional and Scholarly Excellence) by Dr. Broder, available from the ACEP Bookstore, www.acep.org/bookstore.

CME Questions

Qualified, paid subscribers to *Critical Decisions in Emergency Medicine* may receive CME certificates for up to 5 ACEP Category I credits, 5 *AMA PRA Category 1 Credits™,* and 5 AOA Category 2-B credits for answering the following questions. To receive your certificate, go to www.acep.org/newcriticaldecisionstesting and submit your answers online. On achieving a score of 75% or better, you will receive a printable CME certificate. You may submit the answers to these questions at any time within 3 years of the publication date. You will be given appropriate credit for all tests you complete and submit within this time. Answers to this month's questions will be published in next month's issue.

1. What trend should be expected regarding serial serum hCG levels in patients with ectopic pregnancy?
   A. They always decrease
   B. They can increase or decrease
   C. They peak at 1,500 mIU/mL
   D. They stay the same

2. For pregnant patients who have undergone in vitro fertilization, what is the approximate risk of having a heterotopic pregnancy?
   A. 1:100
   B. 1:1,000
   C. 1:10,000
   D. 1:30,000

3. A 30-year-old woman presents with diffuse, crampy abdominal pain that has been present for the past three days and has been getting progressively worse. She has moderate tenderness to palpation in the left adnexal area. A urine hCG is positive. Serum hCG is 3,450 mIU/mL. Transvaginal ultrasonography shows a gestational sac. No free fluid is noted. What is the disposition for this patient?
   A. Consult OB/GYN for presumed ectopic pregnancy
   B. Discharge to home with OB/GYN followup in 48 hours for repeat serum hCG check
   C. Further evaluate with a CT scan of the pelvis
   D. Place patient in the emergency department observation unit for serial abdominal examinations

4. Which of the following is true regarding abdominal pain as a treatment effect during methotrexate therapy?
   A. It rarely occurs
   B. It represents a treatment failure
   C. It resolves on its own within 24 to 48 hours
   D. Onset of pain is approximately one week after start of therapy

5. What is the correct dosage of anti-D immunoglobulin that should be administered to Rh-negative pregnant women who present with vaginal bleeding?
   A. 50 mcg
   B. 50 mg
   C. 100 mcg
   D. 500 mcg

6. Presence on ultrasonography of which of the following has a near 100% positive predictive value for confirming pregnancy?
   A. Double decidual sac
   B. Endometrial stripe
   C. Gestational sac
   D. Yolk sac

7. Within the fallopian tube, what is the most common location of ectopic pregnancy?
   A. Ampulla
   B. Cornua
   C. Fimbria
   D. Interstitium

8. What is the earliest gestational age at which a fetal heart rate can typically be detected on transabdominal ultrasound?
   A. 4 weeks
   B. 5 weeks
   C. 6 weeks
   D. 8 weeks

9. What is the most common risk factor for ectopic pregnancy?
   A. History of pelvic inflammatory disease
   B. History of spontaneous abortion
   C. Prior tubal surgery
   D. Smoking

10. A 27-year-old woman presents to the emergency department with abdominal and shoulder pain that has been present for the past several hours. She notes some nausea and lightheadedness. Her last menstrual period is unknown. Her blood pressure is 85/60 and pulse rate is 111. A urine hCG is positive, and the serum hCG is 1,000 mIU/mL. Which of the following is considered the diagnostic gold standard for this condition?
    A. CT scan
    B. Exploratory laparoscopy
    C. Serial hCG
    D. Transvaginal ultrasonography

11. Which of the following chest tube sizes is appropriate for aspiration of a large primary spontaneous pneumothorax in an adult?
    A. 16F to 22F
    B. 22F to 26F
    C. 26F to 30F
    D. 30F to 34F

12. Which of the following is the initial imaging modality of choice in the diagnosis of spontaneous pneumothorax?
    A. Anteroposterior and lateral decubitus views
    B. Expiratory chest radiographs
    C. Posteroanterior upright chest radiograph
    D. Ultrasonography

13. In general, approximately what percentage of patients with spontaneous pneumothorax will have a recurrence when treated via simple aspiration or intercostal chest tube insertion?
    A. 10%
    B. 30%
    C. 50%
    D. 70%

14. Which of the following patients is at greatest risk for developing spontaneous pneumothorax?
    A. 28-year-old tall male smoker
    B. 34-year-old pregnant woman
    C. 45-year-old male pilot
    D. 54-year-old postmenopausal female smoker

15. A 25-year-old man presents complaining of mild shortness of breath and chest pain that initially was sharp but that is now 2/10 in intensity and achy. Which of the following scenarios would allow the patient to be discharged home?
    A. CT shows emphysematous changes and bilateral bullae with a small bilateral pneumothorax
    B. Initial vital signs are blood pressure 120/82, pulse 112, respiratory rate 24, and pulse oximetry 94%
    C. Posterolateral chest radiograph shows large pneumothorax
    D. Posterolateral chest radiograph shows small pneumothorax

16. A 32-year-old man developed a large spontaneous pneumothorax. He was treated with intercostal tube drainage initially and eventually had a unilateral talc pleurodesis performed with good success. He is to be discharged home today and should be given instructions to avoid which of the following activities?
    A. Business trip in three weeks with a flight from New York to Dallas
    B. Diving in the Bahamas for his anniversary next month
    C. Single-elimination all-night basketball tournament in one month
    D. Training for a full marathon next year

17. At what intervals are repeat chest radiographs recommended for a patient with small primary pneumothorax?
    A. 2 hours after initial intervention and 48 hours after discharge home
    B. 3 hours after initial intervention and 36 hours after discharge home
    C. 6 hours after initial intervention and 24 hours after discharge home
    D. 6 hours after initial intervention and 72 hours after discharge home

18. For which of the following patients would surgical intervention be recommended?
    A. A patient who had full lung reexpansion following intercostal tube insertion
    B. A patient with bilateral small spontaneous pneumothorax
    C. A patient with a persistent air leak three days after intercostal tube insertion
    D. A professional swimmer with a primary spontaneous pneumothorax

19. What is the correct definition of secondary spontaneous pneumothorax?
    A. Pneumothorax occurring after subclavian vein central line placement
    B. Pneumothorax occurring in the presence of underlying lung disease
    C. Pneumothorax occurring with significant cardiorespiratory compromise
    D. Pneumothorax secondary to bleb/bullae rupture

20. What is the most common presenting complaint in a patient with pneumothorax?
    A. Back pain
    B. Chest pain
    C. Palpitations
    D. Shortness of breath

Answer key for June 2013, Volume 27, Number 6

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
A	B	B	D	B	D	A	D	A	C	D	B	A	A	C	D	B	B	B	B

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The Drug Box

Desmopressin

By Jennifer Yee, MD; Summa Health System Emergency Medicine Residency

Hemophilia A is an X-linked recessive disorder resulting in a deficiency of functional amounts of clotting factor VIII, while von Willebrand disease (VWD) is a disorder of impaired synthesis of or dysfunctioning von Willebrand factor (vWF). This factor plays a role in hemostasis by acting as a factor VIII carrier and by forming adhesive bridges between platelets, vascular subendothelial structures, and adjacent platelets. Bleeding manifestations within these disorders require prompt recognition and treatment to limit and ultimately resolve hemorrhage.

Vasopressin is released from the posterior pituitary in response to decreasing blood pressure or rising plasma tonicity. Desmopressin (1-desamino-8-D-arginine vasopressin) is a long-acting synthetic analog of vasopressin. Unlike clotting factor concentrates, desmopressin provides the benefit of mitigating hemorrhage but without the risk of transmission of blood-borne viral infections. Patients should initially be tested to determine if they respond to desmopressin before therapeutic application.

Mechanism of action	Transiently increases serum levels of factor VIII and vWF by stimulating their release from endothelial cells. Factor levels increase approximately 3 fold, peaking between 30 and 60 minutes after infusion.
Indications	Maintain hemostasis and control bleeding in patients with VWD and those with hemophilia A with factor VIII coagulant activity levels above 5%
Dosing	Intravenous: 0.3 mcg/kg (maximum dose, 20 mcg) by infusion over 15 to 30 minutes, every 12 hours for a total of 3 or 4 doses Subcutaneous: 0.3 mcg/kg Intranasal spray: 150 mcg in each nostril for adults; 150 mcg in one nostril for children weighing less than 50 kg
Side effects	Facial flushing, headache, and tachycardia
Estimated cost to hospital and patient	Injection: 4 mcg/mL (10 mL): $349.69 Nasal 0.1 mg/mL (5 mL): $153.46 Nasal 1.5 mg/mL (2.5 mL): $682.80
Contraindication/ precautions	Limit water intake by 75% over the subsequent 24 hours in young children to prevent hyponatremia, which is caused by the drug's intrinsic antidiuretic properties. There have been rare reports of thrombotic events following desmopressin in patients predisposed to thrombus formation.

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