

# Acute appendicitis: Pregnancy complicates this diagnosis

In pregnant women, the clinical signs and test results that typically are used to diagnose appendicitis become unreliable. What do you rely on instead?

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**A**cute appendicitis is the most common extrauterine surgical emergency in pregnancy,<sup>1</sup> occurring in up to 1 in 1,500 pregnancies, and appendectomy is the most common general surgical procedure performed on pregnant women.<sup>2,3</sup> Appendicitis occurs in pregnant women with the same frequency as in nonpregnant women. However, pregnancy itself makes diagnosis difficult, and a delay in diagnosis increases the risk of fetal-maternal mortality.<sup>4,6</sup> The major predictor of mortality is perforation of the appendix; the risk of perforation increases over the term of the pregnancy.<sup>3,4</sup>

Appendicitis can occur at any point in pregnancy, although the condition seems to occur most often during the second trimester. In gravid patients, the incidence of appendicitis is approximately 30% in the first trimester, 45% in the second trimester, and 25% in the third trimester.<sup>7</sup> Pregnancy has not been found to increase the risk of appendicitis, but physiologic and anatomic changes that occur during pregnancy may obscure the diagnosis.<sup>8</sup> A careful history and physical examination can rule out other causes of abdominal pain<sup>4</sup> (see Table 1, page 38).

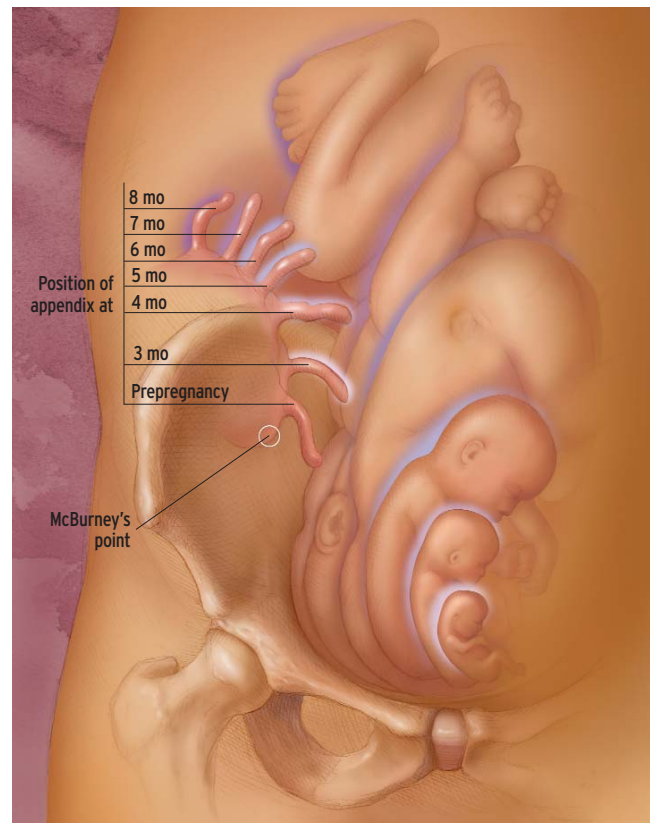
## A DIFFICULT DIAGNOSIS

Right-sided abdominal pain is the most consistent symptom of appendicitis, but as pregnancy progresses, this symptom becomes less reliable.<sup>4</sup> Cappell speculates that nonspecific abdominal tenderness may be present, although rebound and guarding are less frequent as a result of the laxity of the abdominal wall.<sup>9</sup> In addition, GI symptoms of appendicitis such as anorexia, nausea, vomiting, and abdominal discomfort mimic those of early pregnancy.<sup>7</sup>

**Effects of pregnancy** As fetal gestation progresses, making the diagnosis becomes more difficult because the appendix is pushed laterally and superiorly by the expanding uterus.<sup>3,6,9,10</sup> Researchers have shown that the expanding uterus can progressively displace the appendix into the upper right quadrant by as much as 3 cm above McBurney's point<sup>6</sup> (see Figure 1). However, clinical studies have shown that 84% of pregnant women presenting with appendicitis have pain in the right lower quadrant, not the right upper quadrant.<sup>3,7</sup> Clinical signs and laboratory tests used to diagnose appendicitis may be

unreliable because of these anatomic changes and the physiologic differences that occur during pregnancy.<sup>10</sup>

The physiologic increase in maternal blood volume during pregnancy can diminish the signs of tachycardia and hypotension.<sup>10</sup> Additionally, the normal leukocytosis of pregnancy (WBC count as high as 16,000/ $\mu$ L) might mask signs of infection, making this an invariable laboratory value and nonspecific.<sup>3,5,7,8,11</sup> In a retrospective study of 22 pregnant patients with appendicitis, the WBC count was less than 12,000/ $\mu$ L in 54% of the cases.<sup>8</sup> The WBC differential also is not a dependable indicator. Immature WBCs (bands) often



**FIGURE 1.** The growing uterus progressively displaces the appendix in a counterclockwise rotation out of the pelvis into the right upper quadrant.

Here and on the cover: © Molly Borman

increase during nonspecific infection or inflammation. In a majority of pregnant women with appendicitis, bands were not elevated on the WBC differential, making a high band count not specific in these patients.<sup>3,7</sup>

Fever is another unreliable clinical manifestation of appendicitis during pregnancy. In the same retrospective study cited earlier, only 14% of the patients presented with fever.<sup>8</sup> In pregnant women, the history and physical examination, along with a high index of suspicion, are the best indicators for making the diagnosis.<sup>10,12</sup>

**Imaging** The emergent nature of acute appendicitis and the need to avoid unnecessary exploratory surgery in pregnant patients requires a rapid, reliable, and safe test for making this diagnosis.<sup>13</sup> Helical or spiral CT scanning is useful.<sup>3,13</sup> Helical CT scans can be obtained in approximately 15 minutes; scanning is noninvasive; and helical CT is highly sensitive and specific for appendicitis.<sup>13</sup> CT scanning can show an inflamed appendix (more than 6 mm in diameter) and also demonstrates periappendiceal inflammatory changes.<sup>11</sup> In addition, select limited helical scanning limits radiation exposure to approximately 300 milli-radiation absorbed dose (mrad), which is well below the safe level of fetal exposure (5 rad).<sup>13</sup> Rectal contrast alone is a reliable diagnostic tool, as well. This method decreases the risk of systemic reactions to intravenous contrast material and reduces patient discomfort.

Ultrasonography (US) is another noninvasive imaging method used during pregnancy. Because a normal appendix must be identified to rule out appendicitis, US is appropriate when the diagnosis is equivocal by history and physical examination.<sup>11</sup> An advantage of US is its ability to rule out other causes of abdominal pain, such as ectopic pregnancy or corpus luteum cyst, as well.<sup>11</sup> However, visualizing the appendix with a gravid uterus can be difficult, especially in the third trimester; visualization may be improved by placing the patient in the left lateral decubitus position and using the cecum as a landmark.<sup>4,13</sup> But because of its high sensitivity and specificity, CT is now the preferred imaging method.

## TREATMENT

As soon as acute appendicitis is suspected in a pregnant patient, prompt surgical evaluation should be initiated. A delay in surgical intervention increases maternal and fetal

morbidity and mortality rates.<sup>7</sup> As far back as 1908, the importance of the timely diagnosis and treatment was described using this phrase: “the mortality of appendicitis complicating pregnancy is the mortality of delay.”<sup>3</sup>

The greatest risk of potential harm to the mother and fetus is appendiceal perforation. The rate of perforation during pregnancy can be as high as 43%, compared to 19% in the general population.<sup>4,10</sup> In a retrospective study by Fletcher, 12 of 22 (55%) of patients had perforated appendices.<sup>8</sup> The overall perforation rate appears to be highest in the third trimester of pregnancy.<sup>14</sup> Perforations in pregnancy often lead to serious complications, including intraperitoneal infections and fetal death. Fetal mortality increases from 3% to 5% with early appendicitis to 20% with perforation.<sup>10,11,15</sup> The risk also increases with gestational age. Perforation in the third trimester often results in the onset of preterm labor.<sup>10</sup>

Anesthetic concerns in the pregnant patient include teratogenicity of the anesthetic agents and maternal physiologic changes as a result of the agent used.<sup>16</sup> *Teratogenicity* is defined as potential chromosomal damage or carcinogenesis in the fetus. Nearly all analgesics and anesthetics are in pregnancy category C (ie, uncertain safety; no human studies, animal studies show adverse effect).<sup>3</sup> Inhalation and local anesthetics, muscle relaxants, narcotic analgesics, and benzodiazepines are proven, with reasonable certainty, to be safe in pregnancy.<sup>3</sup> Studies of the effects of anesthetic agents on the fetus conclude that morbidity to the fetus is primarily from the underlying disease, not from the anesthesia.<sup>3</sup>

## LAPAROTOMY VERSUS LAPAROSCOPY

The surgical techniques used to treat appendicitis are *exploratory laparotomy* (known as the *open technique*) and *laparoscopic appendectomy*. The best approach to use depends on equipment availability and the surgeon’s experience.<sup>17</sup> Once the decision is made to proceed with surgery, patient preparation includes ensuring adequate hydration; correcting any electrolyte abnormalities; and addressing any pre-existing cardiac, pulmonary, and renal conditions.

**Open technique** In an open procedure, the appendix is accessed through a McBurney (oblique) or Rocky-Davis (transverse) right lower quadrant incision<sup>6</sup> centered over the point of maximum tenderness, a palpable mass, or the anti-

### KEY POINTS

- Appendicitis can occur during any trimester. In gravid patients, the incidence is approximately 30% in the first trimester, 45% in the second trimester, and 25% in the third trimester.
- Right-sided abdominal pain is the most consistent symptom of appendicitis. As pregnancy progresses, however, this symptom becomes less reliable. In addition, GI symptoms of appendicitis such as anorexia, nausea, vomiting, and abdominal discomfort mimic those of early pregnancy.
- The greatest risk of potential harm to the mother and fetus is appendiceal perforation. The rate of perforation during pregnancy can be as high as 43%, compared to 19% in the general population.
- Surgical techniques used to treat appendicitis are the open technique and laparoscopic appendectomy. Regardless of which approach is used, surgery is the optimal treatment.

### COMPETENCIES

●●●● Medical knowledge

●● Interpersonal & communication skills

●● Patient care

● Professionalism

● Practice-based learning and improvement

● Systems-based practice

pated cecum. In a retrospective study of appendectomies performed on pregnant patients, the appendix was located without difficulty in 94% of the incisions made through McBurney's point and 80% of the incisions made above McBurney's point.<sup>6</sup> If the diagnosis is in doubt, a lower mid-line incision is used.<sup>6</sup> An open technique allows for better visualization of the peritoneum, especially as the pregnancy progresses; has a decreased cost compared to laparoscopy; and prevents exposure to carbon dioxide (CO<sub>2</sub>) pneumoperitoneum.<sup>3,11</sup>

**Laparoscopic appendectomy** Initially, pregnancy was considered a contraindication to laparoscopy.<sup>15</sup> However, because of the advances made in laparoscopic surgery, a growing number of reports in the literature suggest that the procedure is safe for pregnant patients. As a result, laparoscopy is being performed on pregnant patients with increasing frequency in many centers.<sup>5</sup>

In general, laparoscopy is well tolerated by both mother and fetus during all three trimesters of pregnancy.<sup>3,5,17</sup> Some advantages of laparoscopy are fewer wound infections, decreased postoperative pain with less narcotic use, and a lower risk of ileus.<sup>5,15,17</sup> Also reported were an earlier return of GI function and ambulation, a shorter hospital stay, and a faster return to routine activity.<sup>15,16</sup> However, overall complication rates were similar between the two procedures in some studies.<sup>17</sup> And an analysis by Carver and associates concluded that no study to date demonstrated a clear advantage of the laparoscopic approach over the open approach.<sup>2</sup>

When performing laparoscopy in pregnant patients, major concerns include potential injury to the uterus, decreased uterine blood flow, the risk of increased intra-abdominal pressure causing preterm labor, and fetal acidosis.<sup>15</sup> The fetus is particularly sensitive to maternal arterial CO<sub>2</sub> (PaCO<sub>2</sub>), and maternal hypercapnia can result in fetal acidosis.<sup>2</sup>

The surgeon should be aware of how pneumoperitoneum used in laparoscopic surgery can induce changes in maternal physiology.<sup>5</sup> Adding pneumoperitoneum to an enlarged uterus limits diaphragm expansion, increases peak airway pressure, decreases thoracic cavity compliance, and increases pleural pressure.<sup>16</sup> All of these can predispose the pregnant patient to hypercapnia and hypoxemia. Any increase in maternal PaCO<sub>2</sub> or decrease in maternal arterial oxygen can affect fetal well-being.<sup>2,16</sup> Intraoperative monitoring of maternal end-tidal CO<sub>2</sub> and fetal heart rate assessment should decrease these risks to the fetus.<sup>2</sup>

**GUIDELINES FOR SURGERY**

The Society of American Gastrointestinal Endoscopic Surgeons (SAGES) published the following recommendations for performing laparoscopic surgery during pregnancy:

- A preoperative obstetric consultation should be obtained.
- Operative intervention should be deferred until the second trimester whenever possible. Fetal risk is lowest during this trimester.
- Pneumatic compression devices should be used whenever possible. Pneumoperitoneum enhances lower extremity

**TABLE 1. Common causes of abdominal pain in the pregnant patient**

<b>Diffuse abdominal pain</b>	
• Acute intermittent porphyria	• Sickle cell crisis
• Early acute appendicitis	• Small bowel obstruction
<b>Flank</b>	
• Acute appendicitis (retrocecal appendix)	• Hydronephrosis of pregnancy
	• Pyelonephritis
<b>Lower abdomen</b>	
• Acute appendicitis	• Renal or ureteral colic
• Adnexal torsion	• Ruptured corpus luteum
• Ectopic pregnancy	• Ruptured ovarian cyst
• Endometriosis	• Tubo-ovarian abscess
• Pelvic inflammatory disease	
<b>Right lower quadrant</b>	
• Acute appendicitis	• Renal or ureteral colic
• Adnexal torsion	• Ruptured corpus luteum
• Ectopic pregnancy	• Ruptured ovarian cyst
• Endometriosis	• Tubo-ovarian abscess
• Pelvic inflammatory disease	
<b>Right upper quadrant</b>	
• Acute appendicitis	• Hemangioma
• Acute cholecystitis	• Hepatic adenoma
• Acute fatty liver of pregnancy	• Hepatitis
• Acute pancreatitis	• Peptic ulcer disease
• Biliary colic	• Pneumothorax
• Gastroesophageal reflux	• Pneumonia
• HELLP syndrome	• Preeclampsia

**Key:** HELLP, hemolysis, elevated liver enzymes, low platelets.

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venous stasis, which is already present in the gravid patient, and pregnancy induces a hypercoagulable state.

- Fetal and uterine status, as well as maternal end-tidal CO<sub>2</sub> and/or arterial blood gases, should be monitored.
- Given the enlarged gravid uterus, an open technique should be used to attain abdominal access.
- The patient should be positioned so that the uterus is shifted off the vena cava.
- Pneumoperitoneum pressures should be 8 to 12 mm Hg and not allowed to exceed 15 mm Hg.<sup>18</sup>

**PREGNANCY-RELATED RISKS**

Surgeons and clinical staff must have a thorough understanding of the physiology of pregnancy, regardless of which surgical technique is used. During the first trimester, the major risks are effects of anesthesia on the fetus secondary to teratogenesis and a miscarriage rate of 12%. In the second trimester,

the miscarriage rate drops to less than 1%, and the rate of preterm labor decreases to 8%. During the third trimester, however, preterm labor and premature delivery rates increase to 30% and continue to increase with advancing gestational age.<sup>15</sup> Therefore, the second trimester is considered the safest time to perform surgery in pregnant patients.<sup>15</sup>

Besides potential anesthetic effects, multiple cardiovascular and pulmonary physiologic changes occur in pregnancy. The surgeon and anesthesiologist's awareness of these changes is important in order to prevent fetal hypoxia and hypotension. The cardiovascular system of the pregnant patient is hyperdynamic with a 40% to 45% increase in total blood volume, leading to increased cardiac output and heart rate.<sup>3,5,10</sup> Also, increased plasma osmolality and interstitial colloid osmotic pressure favors extravasation of fluid into extracellular spaces. Therefore careful fluid replacement perioperatively is essential.

The uterine vessels enlarge throughout pregnancy, and blood flow reaches 450 to 650 mL/min at term.<sup>5</sup> Thus, maternal blood flow and oxygenation are the primary determinates of fetal oxygenation; a compromise in either results in fetal hypoxemia. With the patient in the supine position, compression of the vena cava may decrease venous return and, consequently, cardiac output decreases. Cardiac output can increase up to 20% by placing the patient in the left lateral decubitus position, which displaces the gravid uterus off the inferior vena cava.<sup>5</sup>

Increased oxygen consumption and mechanical displacement of the abdominal organs cause increased minute ventilation, primarily through a 30% to 40% increase in tidal volume.<sup>3</sup> Thus, a compensatory respiratory alkalosis develops and intubation may be more difficult because of increased airway edema later in the pregnancy. A smaller endotracheal tube should be used at this time. Decreased lower esophageal sphincter pressure and delayed gastric emptying can cause an increased risk of aspiration; cricoid pressure (also called the *Sellick maneuver*) should be used to prevent aspiration during intubation.<sup>16</sup>

Preoperative cardiovascular and pulmonary monitoring is important. End-tidal CO<sub>2</sub> should be monitored continuously and maintained between 25 mm and 33 mm; changes should be made by changing minute ventilation.<sup>15</sup>

Fetal monitoring is as essential as maternal monitoring. Perioperative fetal heart rate and uterine activity fetal monitoring are used to assess fetal distress or complications in a viable pregnancy older than 24 weeks.<sup>3,16</sup> A study from the Swedish Health Registry found the preterm delivery rate was 22% if the fetus was older than 23 weeks. Obstetricians may recommend tocolytics perioperatively to prevent preterm labor.<sup>3</sup> The most commonly used tocolytics are terbutaline (Brethine) or magnesium, especially if uterine contractions are detected.<sup>16</sup>

Antibiotics are usually administered prophylactically for uncomplicated appendicitis and are absolutely required when appendicitis is complicated by perforation, abscess, or peritonitis.<sup>9</sup> Penicillin, a cephalosporin; clindamycin (Cleocin); and gentamicin (Garamycin) are considered safe during pregnancy.

Stasis of blood in the lower extremities is common during pregnancy. Fibrinogen, clotting factor VII, and clotting factor XII levels are also increased during pregnancy, thereby increasing the risk of thromboembolic events.<sup>15,16</sup> Gestational hormones, particularly estrogen, contribute to a mild hypercoagulopathy by increasing the synthesis of clotting factors. Therefore prophylaxis against deep venous thrombosis is essential in the pregnant patient.<sup>9</sup>

## CONCLUSION

Appendicitis must be considered in the differential diagnosis when a pregnant woman complains of new-onset abdominal pain. Pain in the right lower quadrant, a thorough history, and physical examination findings are the best indicators for confirming the diagnosis. Clinical symptoms, such as fever and GI complaints, as well as nonspecific laboratory findings are not diagnostic for acute appendicitis in pregnant patients. A delay in diagnosis can lead to perforation and increased maternal and fetal morbidity and mortality. Regardless of which procedure is performed, surgery remains the optimal treatment. Surgeons and obstetricians must educate the pregnant patient about the risks of surgery and the possible effects to the mother and fetus. The patient needs to be reassured about the expected outcomes because of the potential emotional impact on the patient and her family. **JAAPA**

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## REFERENCES

- Anderson B, Nielsen TF. Appendicitis in pregnancy: diagnosis, management and complications. *Acta Obstet Gynecol Scand*. 1999;78(9):758-762.
- Carver TW, Antevil J, Egan JC, Brown CV. Appendectomy during early pregnancy: what is the preferred surgical approach? *Am Surg*. 2005;71(10):809-812.
- Melnick DM, Wahl WL, Dalton VK. Management of general surgical problems in the pregnant patient. *Am J Surg*. 2004;187(2):170-180.
- Bezjian AA. Pelvic masses in pregnancy. *Clin Obstet Gynecol*. 1984;27(2):402-415.
- Stapp K, Falcone T. Laparoscopy in the second trimester of pregnancy. *Obstet Gynecol Clin North Am*. 2004;31(3):485-496.
- Popkin CA, Lopez PP, Cohn SM, et al. The incision of choice for pregnant women with appendicitis is through McBurney's point. *Am J Surg*. 2002;183(1):20-22.
- Mourad J, Elliott JP, Erickson L, Lisboa L. Appendicitis in pregnancy: new information that contradicts long-held clinical beliefs. *Am J Obstet Gynecol*. 2000;182(5):1027-1029.
- Tracey M, Fletcher HS. Appendicitis in pregnancy. *Am Surg*. 2000;66(6):559-560.
- Cappell MS, Friedel D. Abdominal pain during pregnancy. *Gastroenterol Clin North Am*. 2003;32(1):1-58.
- Somani RA, Kaban G, Cuddington G, McArthur R. Appendicitis in pregnancy: a rare presentation. *CMAJ*. 2003;168(8):1020.
- Hardin DM Jr. Acute appendicitis: review and update. *Am Fam Physician*. 1999;60(7):2027-2034.
- Maslovitz S, Gutman G, Lessing JB, et al. The significance of clinical signs and blood indices for the diagnosis of appendicitis during pregnancy. *Gynecol Obstet Invest*. 2003;56(4):188-191.
- Ames Castro M, Shipp TD, Castro EE, et al. The use of helical computed tomography in pregnancy for the diagnosis of acute appendicitis. *Am J Obstet Gynecol*. 2001;184(5):954-957.
- Ueberrueck T, Koch A, Meyer L, et al. Ninety-four appendectomies for suspected acute appendicitis during pregnancy. *World J Surg*. 2004;28(5):508-511.
- Curet MJ. Special problems in laparoscopic surgery. Previous abdominal surgery, obesity, and pregnancy. *Surg Clin North Am*. 2000;80(4):1093-1110.
- Shay DC, Bhavani-Shankar K, Datta S. Laparoscopic surgery during pregnancy. *Anesthesiol Clin North America*. 2001;19(1):57-67.
- Apelgren KN, Cowan BD, Metcalf AM, Scott-Conner CE. Laparoscopic appendectomy and the management of gynecologic pathological conditions found at laparoscopy for presumed appendicitis. *Surg Clin North Am*. 1996;76(3):469-483.
- The Society of American Gastrointestinal and Endoscopic Surgeons (SAGES). Guidelines for laparoscopic surgery during pregnancy. <http://www.sages.org/sagespublication.php?doc=23>. SAGES publication #0023. Published October 2000. Accessed November 19, 2007.