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Abdominal pain during pregnancy

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Abdominal pain is a common complaint of female inpatients and outpatients of all ages [1], including women during their childbearing years, and thus often occurs during pregnancy. Abdominal pain during pregnancy presents unique clinical challenges. First, the differential diagnosis during pregnancy is extensive, in that the abdominal pain may be caused by obstetric or gynecologic disorders related to pregnancy, as well as by intraabdominal diseases incidental to pregnancy.

Second, the clinical presentation and natural history of many abdominal disorders are altered during pregnancy. Third, the diagnostic evaluation is altered and constrained by pregnancy. For example, radiologic tests and invasive examinations raise issues of fetal safety during pregnancy. Fourth, the interests of both the mother and the fetus must be considered in therapy during pregnancy. Usually, these interests do not conflict, because what is good for the mother is generally good for the fetus. Sometimes, however, maternal therapy must be modified to substitute alternative but safer therapy because of concerns about drug teratogenicity (eg, substituting a histamine$_2$ receptor antagonist for misoprostol, an abortifacient that is contraindicated during pregnancy) [2,3]. Rarely, the maternal and fetal interests are diametrically opposed, as in the use of chemotherapy for maternal cancer, a therapy that is potentially life-saving to the mother but life-threatening to the fetus [4]. These conflicts raise significant medical, legal, and ethical issues.

Gastroenterologists, as well as obstetricians, gynecologists, internists, and surgeons, should be familiar with the medical and surgical conditions

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that can present in pregnancy and how these conditions affect and are affected by pregnancy. This article reviews obstetric, gynecologic, medical, and surgical causes of abdominal pain during pregnancy, with a focus on aspects of abdominal diseases unique to pregnancy.

Abdominal pain during pregnancy: general considerations

Neurophysiology of abdominal pain

Nociception involves affective or autonomic reflexes from abdominal viscera to the cerebral cortex involving three levels of neurons. The first-order neurons are either C or A-delta fibers. C fibers are narrow, slowly conducting, and unmyelinated and produce a dull and nonlocalized sensation of pain. A-delta fibers are wider, partly myelinated, and faster conducting and produce a sharp and localized sensation of pain. The first-level afferent neurons travel from abdominal structures to synapse in the dorsal horn of the spinal cord. The second-order neurons cross the midline to the contralateral side of the spinal cord to ascend through the spinothalamic and spinoreticular tracts to the thalamic and reticular areas of the pons and medulla [5]. Third-order neurons travel to the limbic system and sensory cortex where pain is perceived [6–8].

Abdominal pain can be visceral, arising from gastrointestinal organs; parietal, arising from peritoneal irritation; somatic, arising from the abdominal wall; neurologic, arising from diseases affecting abdominal nerves; extraintestinal, from referred pain; or cerebral, from neuropyschiatric disorders or factitious disease. Visceral pain tends to be dull, poorly localized, and perceived in the midabdomen because afferent nerve fibers from abdominal viscera typically are C fibers and receive multisegmental and bilateral afferent innervation from the spinal cord. Visceral pain may be accompanied by autonomic concomitants of nausea, diaphoresis, and pallor. Abdominal viscera are most sensitive to mural stretch. Parietal pain tends to be more acute, intense, and focal because it is conveyed by a mixture of A-delta and C fibers and tends to have more discrete innervation from the spinal cord [9]. Parietal pain is exacerbated by coughing, movement, and deep inspiration. Somatic tissue in skin, subcutaneous tissue, and muscle is innervated predominantly by A-delta nerve fibers so that somatic pain is focal and sharp.

Referred pain is felt remotely from the affected area because of the convergence of visceral and somatic afferent neurons to the same level of the spinal cord and the use of the same second-order neurons. For example, pain from gastrointestinal disorders, such as acute cholecystitis, or pain from obstetric disorders, such as ectopic pregnancy, may be referred to the shoulder or back [10]. Conversely, pain from an extraabdominal condition, such as a migraine headache, may be referred to the abdomen.

Pain can be modified centrally or peripherally by the emotional state or psychologic stress [11,12]. Descending pathways from the cortex, thalamus, and brainstem inhibit nociceptive neural impulses at the level of the spinal cord, providing cerebral control and inhibition of painful sensations [13]. Hormones or inflammatory mediators, such as cytokines, also alter the threshold to noxious stimuli [14,15]. These mechanisms may explain abdominal pain secondary to stress, in support of the hypothesis of hyperalgesia in the irritable bowel syndrome and other functional gastrointestinal disorders [16,17]. Persistent visceral pain is often referred to more superficial structures and often becomes hyperalgesic [18], because of factors such as centrally mediated long-term potentiation, possibly mediated by *N*-methyl-d-aspartate [19–21].

Differential diagnosis of abdominal pain during pregnancy

The differential diagnosis of abdominal pain is extensive. The differential diagnosis of pain varies according to location. Diffuse abdominal pain may arise from

Uremia
Porphyria
Peritonitis
Leaking abdominal aneurysm
Hepatic abscess
Gastroenteritis
Inflammatory bowel disease
Early appendicitis
Pancreatitis
Small bowel obstruction
Malaria
Intestinal pseudoobstruction
Partial intestinal obstruction

Pain in the left upper quadrant can be caused by

Peptic ulcer disease
Perforated peptic ulcer
Splenic infarct or rupture
Splenic abscess
Dissecting aortic aneurysm
Nephrolithiasis
Pyelonephritis
Gastric volvulus
Incarcerated paraesophageal hernia
Esophageal rupture
Esophageal stricture
Mallory-Weiss tear

Mesenteric ischemia
Pneumonia
Rib fracture
Radiculopathy
Pulmonary embolus or infarct

Pain in the right upper quadrant can result from

Peptic ulcer disease
Perforated duodenal ulcer
Hepatitis
Hepatic vascular engorgement
Hepatic hematoma
Hepatic malignancy
Biliary colic
Choledocholithiasis
Cholangitis
Cholecystitis
Preeclampsia or eclampsia
Hemolysis, elevated liver enzymes, and low platelet count (HELLP) syndrome
Pyelonephritis
Nephrolithiasis
Rib fracture
Shingles
Pneumonia
Pulmonary embolus or infarct
Pleural effusion
Radiculopathy
Inferior wall myocardial infarction
Colon cancer

Causes of pain in the right lower quadrant include

Appendicitis
Ruptured Meckel's diverticulum
Crohn's disease
Ovarian cyst rupture
Ovarian torsion
Ovarian tumor
Ruptured ectopic pregnancy
Intussusception
Nephrolithiasis
Cystitis
Pyelonephritis
Trochanteric bursitis

Endometriosis
Uterine leiomyomas
Cecal perforation
Colon cancer

Pain in the left lower quadrant can result from gastrointestinal causes, gynecologic and obstetric causes, and other causes. Gastrointestinal causes include

Diverticulitis
Sigmoid volvulus
Colon cancer
Colonic perforation
Urinary tract infection
Small bowel obstruction
Inflammatory bowel disease
Irritable bowel disease
Mesenteric ischemia

Gynecologic and obstetric causes of left lower quadrant abdominal pain include

Ruptured ectopic pregnancy
Ovarian cyst rupture
Pelvic inflammatory disease
Tubo-ovarian abscess
Uterine leiomyomas (including rupture or necrosis)
Abortion (threatened, incomplete, or complete)
Ovarian/adnexal mass
Acute salpingitis
Endometriosis
Ruptured corpus luteum
Cancer of cervix or ovary

Other causes of left lower quadrant abdominal pain are

Nephrolithiasis
Pyelonephritis
Leaking abdominal aneurysm

The abdominal pain is somewhat delimited by the pain location (Table 1). Conditions range from minor to life-threatening. In addition, physiologic changes during pregnancy may cause abdominal symptoms. Nausea, emesis, early satiety, bloating, and pyrosis are common during pregnancy. Serious disorders that produce these symptoms may, therefore, be difficult to distinguish from physiologic changes during pregnancy. Serious symptoms should not be dismissed as normal during pregnancy without a careful history and appropriate evaluation.

Table 1
Common causes of acute, severe abdominal pain in the pregnant woman

Condition	Location	Character	Radiation
Ruptured ectopic pregnancy	Lower abdominal or pelvic	Localized, severe	None
Pelvic inflammatory disease	Lower abdominal or pelvic	Gradual in onset, localized	Flanks and thighs
Appendicitis	First periumbilical, later RLQ (RUQ in late pregnancy)	Gradual in onset, focal in RLQ	Back/flank
Acute cholecystitis	RUQ	Focal	Right scapula, shoulder, or back
Pancreatitis	Epigastric	Localized, boring	Middle of back
Perforated peptic ulcer	Epigastric or RUQ	Burning, boring	Right back
Urolithiasis	Abdomen or flanks	Varies from intermittent and aching to severe and unremitting	Groin

Abbreviations: RUQ, right upper quadrant; RLQ, right lower quadrant.

In the medical history, the pain intensity, nature, temporal pattern, radiation pattern, exacerbating factors, and alleviating factors help narrow the differential diagnosis. The abdominal pain is progressively increasing in appendicitis but is nonprogressive in viral gastroenteritis. The pain from small intestinal obstruction may be intermittent but is severe [22]. Renal and biliary colic also produce a waxing and waning intensity of pain. Acute cholecystitis is associated with right upper quadrant pain, as well as with pain referred to the right shoulder. The pain of acute pancreatitis is often boring in quality, located in the abdominal midline and radiating to the back. Careful physical examination of the abdomen including inspection, palpation, and auscultation can further pinpoint the cause of the pain. Laboratory evaluation of significant abdominal pain routinely includes a hemogram, serum electrolytes, and liver function tests, and often includes a leukocyte differential, coagulation profile, and serum amylase determination. In evaluating the laboratory results, gestational changes in normative values, as described later, must be considered. Radiologic tests may be extremely helpful diagnostically, but the choice of radiologic imaging is constrained by the pregnancy, as discussed later.

The character, severity, localization, or instigating factors of abdominal pain often vary with time. For example, acute appendicitis typically changes from a dull, poorly localized, moderate pain to an intense and focal pain as the inflammation extends from the appendiceal wall to the surrounding peritoneum. When the diagnosis and therapy is uncertain, close and vigilant monitoring by a surgical team, with frequent abdominal examination and regular laboratory tests, can often clarify the diagnosis.

Occasionally, the pregnancy is not known by the patient or is not revealed to the physician, particularly in early pregnancy, when physical

findings are absent. The physician should be vigilant for possible pregnancy in a fertile woman with abdominal pain, particularly in the setting of missed menses, because pregnancy affects the differential diagnosis, clinical evaluation, and mode of therapy. Pregnancy tests should be performed early in the evaluation of abdominal pain in a fertile woman. Pregnancy is assayed by radioimmunoassay (RIA) or enzyme-linked immunoassay (ELISA) determination of the *B*-unit of human chorionic gonadotropin (hCG) in urine or serum [23].

Physiologic effects of pregnancy on abdominal disorders

Abdominal assessment during pregnancy is modified by displacement of abdominal viscera by the expanding gravid uterus [24]. For example, the location of maximal abdominal pain and tenderness from acute appendicitis migrates superiorly and laterally as the appendix is displaced by the growing gravid uterus [25]. A rigid abdomen with rebound tenderness remains a valid indicator of peritonitis during pregnancy, but abdominal wall laxity in late pregnancy might mask the classic signs of peritonitis [26,27]. An abdominal mass may be missed on physical examination because of the presence of the enlarged gravid uterus [4].

Physiologic alterations of laboratory values during pregnancy must be appreciated, including mild leukocytosis, physiologic anemia of pregnancy, mild dilutional hypoalbuminemia, mildly increased alkaline phosphatase level, and electrolyte changes, particularly mild hyponatremia [28–30]. The erythrocyte sedimentation rate is physiologically elevated and thus is a less reliable monitor of inflammatory activity during pregnancy [31]. Gestational hormones, particularly estrogen, contribute to a mild hypercoagulopathy during pregnancy by increasing the synthesis of clotting factors [32]. Thromboembolic phenomena are also promoted by intraabdominal vascular stasis resulting from compression by the enlarged gravid uterus. Urinary stasis and ureteral dilatation are promoted during pregnancy by urinary tract muscle relaxation induced by progesterone and by mechanical compression of the ureters by the fetal skull [33]. The changes in glucose serum levels during pregnancy are complex. Normal pregnancy is characterized by fasting hypoglycemia, postprandial hyperglycemia, and hyperinsulinemia [34]. Strict control of the serum glucose level is important in diabetic patients for proper fetal development [35].

Mucosal immunity may be diminished during pregnancy as part of physiologic immunologic tolerance of the foreign fetal antigens in the uterus [36]. This reduced mucosal immunity contributes to an increased rate of pyelonephritis during pregnancy. Pregnancy promotes cholelithiasis because of increased cholesterol synthesis and gallbladder hypomotility related to gestational hormones.

The fetus poorly tolerates maternal hypotension, hypovolemia, anemia, and hypoxia. This intolerance affects the type and timing of therapy for

abdominal disorders during pregnancy. The gravid uterus can compress the inferior vena cava in the supine position and thereby compromise venous return, aggravating systemic hypoperfusion from hypovolemia or gastrointestinal bleeding. Simply turning the patient to the left side to displace the uterus may relieve this compression, improve venous return, and normalize the blood pressure [29]. During pregnancy the blood pressure normally declines modestly. A rise in blood pressure during pregnancy may, therefore, portend preeclampsia or eclampsia.

Diagnostic imaging during pregnancy

Fetal safety during diagnostic imaging is a concern for pregnant patients and pregnant medical personnel. Ultrasonography is considered safe during pregnancy and is the preferred imaging modality for abdominal pain during pregnancy [37,38]. Unfortunately, the test sensitivity depends on operator technique, patient cooperation, and patient anatomy, in that sensitivity is decreased by abdominal fat and intestinal gas [38]. Magnetic resonance imaging (MRI) is preferable to computerized tomography (CT) scanning during pregnancy to avoid ionizing radiation, but gadolinium administration should be avoided during the first trimester [39–43]. Rapid-sequence MR imaging is preferable to conventional MR imaging because of the briefer exposure [41]. The patient should undergo counseling before diagnostic roentgenography.

Data concerning fetal malformations, growth retardation, and mortality from ionizing radiation are derived from past experience, especially from Japanese atomic bomb survivors. Radiation can cause chromosomal mutations and neurologic abnormalities including mental retardation and moderately increases the risk of childhood leukemia [43,44]. Radiation dosage is the most important risk factor, but fetal age at exposure and proximity to the radiation source are also important [43,44]. Fetal mortality is greatest from radiation exposure during the first week after conception, before oocyte implantation [40,43,44]. Exposure to more than 15 rads during the second and third trimesters or more than 5 rads during the first trimester, when the risk of neurologic malformations is greatest, should prompt consideration of elective termination of pregnancy [40,43–45]. Diagnostic studies with the most radiation exposure, such as intravenous pyelography or barium enema, typically expose the fetus to less than 1 rad [40,42,45]. Thus, one diagnostic fluoroscopic procedure is relatively safe in pregnancy. A medical physicist can estimate the fetal exposure from the study [40,42]. Fetal radiation exposure should be minimized by shielding, collimation, and rapid-sequence studies.

Endoscopy during pregnancy

Endoscopy is often performed in the evaluation of abdominal pain in nonpregnant patients. Flexible sigmoidoscopy is performed to evaluate

minor lower gastrointestinal complaints including rectal symptoms, and esophagogastroduodenoscopy (EGD) is performed to evaluate epigastric pain, dyspepsia, or pyrosis. Although endoscopy is extremely safe in the general population, endoscopy during pregnancy raises the unique issue of fetal safety. Endoscopy could potentially cause fetal complications from medication teratogenicity, placental abruption or fetal trauma during endoscopic intubation, cardiac arrhythmias, systemic hypotension or hypertension, and transient hypoxia. Medication teratogenicity is of particular concern during the first trimester during organogenesis.

Sigmoidoscopy seems to be relatively safe during pregnancy. No woman suffered endoscopic complications in a study of 46 patients undergoing sigmoidoscopy during pregnancy [46]. Excluding 1 unknown pregnancy outcome and 4 voluntary abortions, 38 of 41 pregnant women delivered healthy infants, including 27 at full term. Their mean Apgar scores were not significantly different from the mean national Apgar scores. Moreover, study patients did not have a worse outcome than pregnant controls matched for sigmoidoscopy indications who did not undergo sigmoidoscopy, because of maternal and physician choice, in terms of mean infant Apgar scores at birth, and in terms of the rates of fetal or neonatal demise, premature delivery, low birth weight, and delivery by cesarean section. Additionally, no endoscopic complications were reported in 13 flexible sigmoidoscopies during pregnancy analyzed by a mailed survey of 3300 gastroenterologists [47]. All pregnancies resulted in delivery of healthy infants at term.

These studies, in addition to scattered case reports, strongly suggest that sigmoidoscopy during pregnancy does not induce labor or cause congenital malformations, is not contraindicated, and should be strongly considered in medically stable patients with important indications. Sigmoidoscopy is not recommended during pregnancy for weak indications, such as routine cancer screening or surveillance, which can be deferred until at least 6 weeks postpartum. Sigmoidoscopy should be performed with maternal monitoring by electrocardiography, sphygmomanometry, and pulse oximetry, after obstetric consultation and medical stabilization. Analgesic medication is minimized during sigmoidoscopy, especially during the first trimester. The safety of EGD during pregnancy is peripheral to this article but is considered in detail in a companion article on the safety of endoscopy during pregnancy.

Team approach and informed consent

A team approach with consultation and referral helps optimize the management of complex diseases during pregnancy that affect both the mother and the fetus and that require disparate areas of expertise. The gastroenterologist contemplating endoscopy may consult with the obstetrician about the optimal procedure timing and with the anesthesiologist about analgesia during endoscopy. The internist may discuss with the radiologist the benefits versus risks of radiologic tests, and the radiologist may in turn consult

with a physicist about methods to monitor and reduce fetal radiation exposure. The surgeon may consult with the obstetrician about the timing of abdominal surgery in relation to the pregnancy and about the possibility of performing simultaneous cesarean section and abdominal surgery. Complex gastrointestinal or surgical problems during pregnancy may be best handled at a tertiary hospital with the requisite experience and expertise.

The patient should be informed about the consequences to both herself and her fetus of diagnostic tests and therapy and should be actively involved in medical decisions. The patient makes the decision, under the vigilant guidance of the experts, and with advice by the father, family, and friends. When an intervention, such as roentgenographic tests, entails significant potential fetal risk, a signed, witnessed, and informed consent is recommended, even though this intervention would be routine and not require consent in the nonpregnant patient.

Obstetric disorders

Ectopic pregnancy

In ectopic pregnancy (EP), the blastocyst implants at a site other than the uterine endometrium. Ninety-five percent of EPs implant in the oviduct, including the ampulla, isthmus, or fimbria [23]. The remainder implant in the uterine interstitium, cervix, ovaries, or elsewhere in the abdomen [23,48].

Risk factors for EP include prior EP [49,50], advanced maternal age [51], prior pelvic inflammatory disease (PID) [52], tubal surgery [53], laboratory-assisted reproduction [54], previous abortion [55], endometriosis [56], preexisting fallopian, adnexal, or uterine pathology [57], and prior complicated abdominal surgery, such as ruptured appendicitis (Box 1) [58]. Other reported associations include cigarette smoking [59], low socioeconomic status, and black race [60]. Some cases are idiopathic. Ectopic embryos do not have more chromosomal mutations than intrauterine embryos [61].

The incidence of EP has increased in the United States from 0.5% of pregnancies, or 18,000 women in 1970, to 2.0% of pregnancies, or 110,000 women in 1992 [62,63], as a result of more fallopian tube surgery, more laboratory-assisted pregnancies, better PID therapy, more accurate detection of early pregnancy, and use of intrauterine devices or low-dose progestational agents which prevent intrauterine, but not ectopic, pregnancy [64–66]. The age of presentation depends on the cause: sexually active young women tend to have EP from PID, whereas older women tend to have EP from laboratory-assisted reproduction and prior tubal surgery [67].

About 70% of patients present with the classic history of abdominopelvic pain and vaginal bleeding after a period of amenorrhea [48]. The pain may initially be diffuse and vague but later becomes focal and severe [68,69]. The pain may initially be contralateral to the EP because of a leaking corpus luteum [70]. The implantation site affects the clinical presentation.

Box 1. Clinical presentation and diagnosis of ectopic pregnancy

Epidemiology

0.5% of all pregnancies
10% in women with prior ectopic pregnancy

Risk factors

Fallopian tube pathology (congenital abnormalities, including diethylstilbesterol [DES] exposure, salpingitis)
Prior fallopian tube surgery (tubal ligation, prior EP)
Previous abortion (especially induced abortion)
Endometriosis
Intrauterine device (IUD) use
Hormonally altered tubal transport (estrogen or progesterone administration)
Ovulation induction
In vitro fertilization (including intrafallopian transfer)

Clinical presentation

Abdominopelvic pain
Amenorrhea followed by vaginal bleeding (variable)
Abdominal mass
Hypotension, syncope (from massive fluid loss)

Diagnosis

Beta-human chorionic gonadotropin (β-hCG) level
Serum progesterone level
Ultrasound evaluation (transabdominal or transvaginal ultrasound)
Culdocentesis
Suction curettage–chorionic villi sampling
Laparascopy
Laparotomy

Symptoms can occur within 2 weeks of a missed menses when the conceptus implants in the narrow proximal isthmus but usually occur more than 6 weeks after a missed menses when the conceptus implants in the wider distal ampulla [71]. Physical signs vary greatly but may include mild uteromegaly, cervical tenderness, and an adnexal mass [72].

The diagnosis is initially missed in nearly one half of cases because of the insensitivity of the patient history and physical examination [72,73]. The mean serum progesterone level is higher in a viable intrauterine pregnancy

than in EP, but this test is not clinically useful because the individual values sometimes overlap [74,75]. A viable intrauterine pregnancy is often differentiated from EP by serial β-hCG determinations, in that the β-hCG level increases faster with a viable intrauterine pregnancy than with EP [37,69]. Ectopic pregnancy is, however, best differentiated from intrauterine pregnancy by pelvic ultrasonography with simultaneous β-hCG determination [38,76]. Ultrasound findings in an intrauterine pregnancy include uteromegaly and a double-decidual sac sign, produced by separation between the decidua vera and capsularis [45]. This sac sign is usually detected by conventional abdominal ultrasonography at about 4 weeks of gestation, when the β-hCG level is greater than 6500 IU/L (the discriminatory zone) [73], and by transvaginal ultrasonography (TVUS) at about 2 weeks of gestation when the β-hCG level is greater than 1500 IU/L because of greater test sensitivity [75]. Absence of this sign on abdominal ultrasound study when the β-hCG level is greater than 6500 IU/L, or on TVUS when the β-hCG level is greater than 1500 IU/L suggests EP [75]. Both the sensitivity and specificity of TVUS in conjunction with serum β-hCG level determination are nearly 90% [37,77]. Absence of chorionic villi in a uterine curettage can confirm the diagnosis of EP [70].

Ectopic pregnancy is increasingly managed medically [76,78,79]. Patients with early, small, and nonruptured EPs with low and declining serum β-hCG levels are occasionally monitored without therapy, because these characteristics are predictors of spontaneous resorption [80]. Methotrexate is injected intramuscularly to promote EP absorption in hemodynamically stable women with a nonruptured tubal EP when the mass is less than 3.5 cm in diameter, gestation is less than 6 weeks, fetal heart sounds are not detectable, the β-hCG level is low, and bleeding is not evident [81]. The serum β-hCG level and sonogram should be repeated to verify therapeutic success [80].

Laparoscopy with salpingostomy or, occasionally, salpingotomy is recommended for EPs smaller than 2 cm in diameter in the distal third of the oviduct without rupture. In other cases, segmental resection and anastomosis are required [48].

The EP ruptures and hemorrhages in about 5% of cases. Rupture can cause diffuse abdominal pain, rebound tenderness, hypotension, confusion, syncope, anemia, and leukocytosis [68,69]. Signs and symptoms are variable [82], however. Shoulder pain suggests free intraperitoneal fluid from intraperitoneal hemorrhage [83].

Culdocentesis can detect hemoperitoneum but is now rarely performed to diagnose rupture because ultrasound is so sensitive and noninvasive. Moreover, a nonbloody aspirate during culdocentesis does not exclude hemoperitoneum in patients with adhesions from prior salpingitis or peritonitis [69]. Ectopic pregnancy rupture requires expedient laparotomy, with salpingectomy or hysterectomy, after fluid resuscitation, even if the patient is hemodynamically stable [56]. Preoperative abdominal ultrasound helps guide the surgeon.

Ectopic pregnancy causes about 10% of all maternal mortality [84]. Mortality from EP has decreased sharply during the last 30 years to a current level of 0.4% but remains higher in minority women [37,62]. Advances in ultrasonography have contributed to earlier diagnosis, a decreased rate of rupture, and the declining mortality [38,76].

Abdominal pregnancy

Abdominal pregnancy, in which the fetus grows in the peritoneal cavity, occurs in about 1.0 of 10,000 pregnancies. It usually arises from intraperitoneal rupture of a tubal pregnancy. Rarely, the blastocyst implants on the liver or spleen. Common symptoms and signs of abdominal pregnancy include abdominal pain, abdominal tenderness, a closed noneffaced cervix, and a palpable mass distinct from the uterus [85]. Sonography and other radiologic modalities, as well as serial β-hCG determinations are used to detect and localize an abdominal pregnancy. Surgery is usually necessary because of the risk of rupture and hemorrhage [48]. Without surgery, abdominal pregnancy may also result in a lithopedion, an abscess, or rarely a viable infant [63]. Small, uncomplicated abdominal pregnancies can be terminated by methotrexate administration. Resolution is monitored by abdominal sonography and serial β-hCG determinations. The placenta is often left in the abdomen after methotrexate administration to avoid intraoperative hemorrhage [63].

Heterotopic pregnancy

In heterotopic pregnancy, intrauterine and ectopic pregnancies coexist. The incidence is about 1 in 5000 pregnancies [70]. The incidence has increased exponentially during the last 2 decades because of intrauterine device (IUD) usage; PID [54,70]; and increasing infertility treatment with pharmacologic ovulation induction, tubal surgery, and assisted reproduction procedures [70]. Abdominal pain is the most common symptom. Serum β-hCG levels are less helpful than in EP because of the concurrent intrauterine pregnancy [86]. Abdominal ultrasound is sometimes diagnostic, but laparotomy may be required for the diagnosis [54]. The management is complicated by the need to maintain the viable intrauterine pregnancy. Laparoscopy with intraabdominal aspiration may be performed for a small heterotopic pregnancy, but an advanced heterotopic pregnancy requires laparotomy [63].

Spontaneous abortion

Spontaneous abortion, whether threatened, incomplete, or complete, typically presents with vaginal bleeding followed by diffuse, crampy lower abdominal or pelvic pain [55]. Some patients have no pain or only a backache [55]. The pain from spontaneous abortion tends to be milder and

more diffuse than that of EP [72]. Medically induced abortion also causes crampy abdominal pain because of prostaglandin administration [87].

Fetal viability is assessed by serum β-hCG levels, serum progesterone levels, and abdominal ultrasonography. Threatened abortion is generally treated by bed rest and analgesia and is sometimes treated by progesterone administration to help preserve the pregnancy [88].

Placental abruption

In placental abruption the placenta prematurely separates from the uterine wall. Placental abruption occurs in about 1 of 80 deliveries [89]. Risk factors include blunt abdominal trauma, advanced maternal age, multiparity, prior abruption, cocaine abuse, chronic hypertension, preeclampsia or eclampsia, premature rupture of membranes, hypercoagulopathies, and uterine leiomyomas [89,90]. Eighty percent of women with placental abruption have vaginal bleeding. Abdominal pain is common and occasionally is severe [72]. Most patients exhibit uterine tenderness and frequent uterine contractions. Severe abruption is associated with maternal disseminated intravascular coagulation (DIC), renal failure, and shock and with fetal distress [89]. Sonography is only moderately sensitive because the echogenicity of fresh blood resembles that of normal placenta [38]. Treatment includes intravenous fluid administration for hypovolemia, packed erythrocyte transfusions for hemorrhage, and prompt delivery of a mature fetus by cesarean section to control the maternal hemorrhage and potentially salvage the fetus.

Placenta previa

In placenta previa the placenta is near or over the cervical os so that the os is partially or completely obstructed. Risk factors include advanced maternal age, multiparity, cigarette smoking, and prior cesarean section [91]. The incidence is about 1 in 300 pregnancies [92]. Placenta previa presents in late pregnancy with vaginal hemorrhage, occasionally associated with abdominal pain or painful uterine contractions. The differential diagnosis includes threatened abortion, EP, pregnancy-related liver disease, appendicitis, acute cholecystitis, ovarian torsion, and premature labor. Placenta previa usually presents in the second half of pregnancy, whereas EP presents in the first half.

Sonography is usually diagnostic [38]. Digital or instrumental probing of the cervix should be avoided, because these maneuvers can precipitate massive vaginal hemorrhage [89]. Placenta previa usually requires cesarean section when the fetus is sufficiently mature.

Placenta previa may be associated with an abnormally adherent placenta. In placenta accreta the placental villi are attached to the myometrium; in placenta increta the villi invade the myometrium; and in placenta percreta the villi penetrate up to the uterine serosa [93]. The overall incidence is 1 in 2000 pregnancies [94]. Risk factors include multiparity, prior cesarean sections, prior placenta previa, uterine infection, and prior uterine curettage

[93]. These disorders are usually diagnosed intrapartum when they manifest as hemorrhage during placental delivery [95]. Placenta percreta occasionally causes antepartum abdominal pain, vaginal bleeding, or hematuria. Intrapartum hemorrhage is treated by fluid resuscitation, correction of coagulopathy, blood transfusions, and by surgical ligation of the bleeding vessel, selective angiographic embolization of the bleeding vessel, or hysterectomy [95].

Trophoblastic proliferations

Gestational trophoblastic proliferations include hydatiform mole, invasive mole, and choriocarcinoma. Hydatiform mole arises from androgenesis, in which an ovum is fertilized by a paternal haploid sperm that replicates without any maternal chromosomal contribution [96]. Hydatiform mole usually produces painless vaginal bleeding. Abdominal sonogram is usually diagnostic. Treatment consists of mole evacuation. About 10% of moles progress to gestational trophoblastic tumors [97].

The most common clinical findings with choriocarcinoma are an abdominal mass and vaginal bleeding, but abdominal pain may occur [98]. Clinical symptoms usually occur after term pregnancy, abortion, or incomplete evacuation of a hydatiform mole. The diagnosis is suggested by persistently elevated β-hCG levels in the absence of a pregnancy. Chemotherapy is indicated for metastatic disease. There is a high cure rate.

Premature labor

Premature (preterm) labor is the premature onset of uterine contractions that may result in premature birth [99]. Cervical os incompetence, uterine infection, and premature rupture of membranes (PROM) are etiologic factors [99]. Symptoms include vaginal discharge or spotting, lower abdominal pain, back pain, urinary urgency, and vaginal pressure. Both the diagnosis and therapy are evolving. Cervical examination is followed by external and internal fetal monitoring and high-resolution sonography. Tocolytic therapy is usually recommended [99].

Gynecologic disorders

Adnexal masses

Ultrasonography has increased the rate of detection of adnexal masses during pregnancy to 2% [100]. The pathology ranges from asymptomatic nonneoplastic ovarian cysts to the surgical emergencies of ovarian torsion, ruptured ovarian cyst, and tubo-ovarian abscess. About half of adnexal masses are less than 5 cm in diameter, about one quarter are between 5 and 10 cm in diameter, and about one quarter are more than 10 cm in diameter

[101]. Ninety-five percent are unilateral [102]. Most adnexal masses are nonneoplastic cysts, including the corpus luteum cyst and the follicle cyst [102]. Both of these cysts usually involute by midterm [38]. Cystic teratomas and cystadenomas are the most common benign ovarian neoplasms during pregnancy [103,104]. Malignancies, including germ cell tumors, low-grade ovarian cancers, and invasive epithelial ovarian cancers, comprise 3% of ovarian masses during pregnancy, for an incidence of 1 in 5000 pregnancies [103,105]. Most women with ovarian cancer present with stage I disease during pregnancy [105]. Cancers from the gastrointestinal tract or elsewhere rarely metastasize to the ovaries [106].

Most adnexal masses are asymptomatic and are incidentally detected by sonography [38,101,102]. Even ovarian cancer is often asymptomatic [82,103]. Symptoms can include vague abdominal pain, abdominal distension, and urinary frequency [103]. Torsion, hemorrhage, or rupture produces severe abdominal pain. Ten percent to 15% of adnexal masses undergo torsion [103]. Germ cell tumors may cause endocrine dysfunction, especially virilization [105].

The management of an ovarian mass during pregnancy is controversial [100]. Abdominal sonography is highly sensitive at mass detection but is insufficiently accurate at distinguishing malignant from benign lesions [38]. Surgery is indicated for likely or certain carcinoma or for an acute abdomen caused by complications such as torsion or hemorrhage. Asymptomatic ovarian masses with benign sonographic features are usually followed closely by serial sonography into the second trimester, the optimal time for abdominal surgery in terms of maternal and fetal safety [102,103,105]. First-trimester surgery is associated with fetal wastage, and third-trimester surgery is associated with premature labor. Laparoscopy often suffices to extirpate the mass while preserving the pregnancy [107]. Patients with malignancy detected during late pregnancy are candidates for prompt cesarean section [100,103]. Prognosis depends on the histologic grade and pathologic stage of the cancer [103,105,107].

Adnexal torsion

Adnexal torsion occurs in about 1 of 1800 pregnancies, an incidence similar to that of acute appendicitis [108]. About one quarter of adnexal torsions occur during pregnancy [109], because of the greater laxity of the tissue supporting the ovaries and oviducts during pregnancy [110]. Torsion usually occurs between the sixth and fourteenth weeks of gestation. Both ovarian cysts and tumors, particularly the benign cystic teratoma, may undergo torsion, but many torsions are idiopathic or occur about extra-ovarian structures [111]. Right-sided torsion is more common than left-sided torsion [109,111].

The clinical presentation is variable [111,112]. The lower abdominal pain is often sharp and sudden in onset and may last from several hours to days.

Intermittent pain may indicate detorsion or devitalization of sensory nerves [108]. Patients often have nausea and emesis. Signs include unilateral lower quadrant tenderness, a palpable adnexal mass, cervical tenderness, or rebound tenderness from peritonitis [111]. Leukocytosis is common.

The diagnosis is often missed. Right-sided adnexal torsion may be difficult to differentiate from appendicitis. Other diagnostic considerations include a ruptured ovarian cyst or EP [72]. Ultrasonography, including duplex scanning, is valuable in the detection of adnexal masses, particularly cysts, but additional diagnostic imaging tests may be necessary. Adnexal torsion, diagnosed before tissue necrosis, is managed with adnexa-sparing laparoscopic detorsion, followed by progesterone therapy if the corpus luteum is removed [113]. Laparotomy with salpingo-oophorectomy is necessary if necrosis or peritonitis has occurred.

Pelvic inflammatory disease

The term pelvic inflammatory disease (PID) refers to infection of the upper genital tract including the oviducts. It is characterized by the triad of lower abdominal pain, pyrexia, and vaginal discharge. Management of PID during gestation is complicated in terms of antibiotic selection and whether to continue the pregnancy [114]. Complications include salpingitis and tubo-ovarian abscess. Patients may become infertile or have a high risk for EP [67,115,116].

Tubo-ovarian abscess

Tubo-ovarian abscess is an emergency associated with maternal mortality and fetal wastage [115]. It can result from pelvic surgery, assisted reproduction, bowel perforation, appendicitis, infected EP, pelvic malignancy, and PID, especially with chlamydial infection [116,117]. Abdominal pain, pyrexia, a palpable mass, and leukocytosis commonly occur. Magnetic resonance imaging, CT scanning, or sonography are helpful in the diagnosis, but laparoscopy is often required for confirmation. Treatment includes fluid resuscitation, parenteral antibiotics, and expedient surgery unless the abscess is small, well contained, and amenable to radiologic drainage [118].

Endometriosis

Endometriosis is a common cause of abdominal pain in younger women. Endometriosis usually does not cause infertility; women with endometriosis usually have an uncomplicated pregnancy and delivery [119]. Ovarian endometriosis is associated with genetic abnormalities and with clear cell and endometrioid carcinoma [120]. Endometrioid cysts account for about 4% of adnexal masses during pregnancy. Peritonitis from endometrial cyst rupture may be difficult to differentiate from appendicitis or EP [121].

Uterine leiomyoma

Uterine leiomyomas (fibroids) are well-circumscribed, benign, smooth muscle tumors. Careful pathologic examination reveals up to 80% of women of reproductive age have uterine leiomyomas [122], but only about 4% of pregnant women have sonographically evident uterine leiomyomas, about 12% of which are multiple [123]. Symptoms include uterine bleeding, pelvic pressure, urinary urgency, and abdominal pain. Large and strategically located leiomyomas can cause infertility [124]. Small leiomyomas are usually asymptomatic.

Leiomyomas tend to become smaller during pregnancy, and leiomyomas initially less than 5 cm in diameter usually involute completely during pregnancy [125]. Complications occur in about 1 in 500 pregnancies [126]. Large leiomyomas can undergo hemorrhagic infarction resulting in the painful myoma syndrome [127]. Symptoms may be minimal or may include severe abdominal pain, nausea, emesis, and pyrexia [128]. Ultrasonography and MR imaging are usually diagnostic [129]. Treatment consists of bed rest and nonsteroidal anti-inflammatory drugs (NSAIDs), but these drugs should be avoided after the thirty-fourth week of gestation because they affect labor [126,127]. Other complications of leiomyomas are premature rupture of membranes, placental abnormalities, uterine rupture (especially after prior myomectomy), dystocia, more frequent cesarean delivery, postpartum hemorrhage, and puerperal sepsis [130].

Uterine rupture

Uterine rupture is rare during pregnancy. Risk factors include prior cesarean section, especially with lower uterine incision, pharmacologic induction of labor with oxytocin or prostaglandins, multiparity, placental percreta, fetal malpresentation, and blunt trauma [131,132]. Patients often present in shock with diffuse abdominal pain. Treatment includes fluid resuscitation, emergency surgery, and fetal delivery. Hysterectomy is often required. Fetal demise is likely with intraabdominal expulsion of the fetus [131,132].

Gastrointestinal disorders

Acute appendicitis

Acute appendicitis is the most common nonobstetric surgical emergency during pregnancy, with an incidence of about 1.0 in 1000 pregnancies [27,133,134]. Appendicitis may occur at any time during pregnancy but is slightly more likely during the second trimester [27,135]. Pregnancy does not predispose to appendicitis [133]. Appendiceal obstruction, usually from an appendicolith, is the primary pathophysiologic event, although stasis and other factors are also implicated [135]. As the appendiceal lumen distends,

the patient initially experiences poorly localized pain [24]. Severe luminal distension, mural inflammation and edema, and bacterial translocation produce somatic pain that becomes severe and well localized in the right lower quadrant [22].

Although abdominal pain is often localized to the right lower quadrant at McBurney's point, displacement of the appendix by the gravid uterus during late pregnancy may cause the point of maximal abdominal pain and tenderness to migrate superiorly and laterally from McBurney's point [25]. Other clinical findings include anorexia, nausea, emesis, pyrexia, tachycardia, and abdominal tenderness [136]. Periappendiceal inflammation or peritonitis causes involuntary guarding and rebound tenderness. Involuntary guarding and rebound tenderness are less reliable signs of peritonitis in late pregnancy because of abdominal wall laxity [26,27]. Rectal or pelvic tenderness may occur in early pregnancy but is unusual in late pregnancy as the appendix migrates from its pelvic location [10,26]. Patients may have significant leukocytosis, a predominance of neutrophils in the leukocyte differential, an abnormal urinalysis, and nonspecific electrolyte abnormalities [137,138].

The diagnosis is made clinically without overreliance on radiologic imaging. Sonography may demonstrate appendiceal mural thickening and periappendiceal fluid, but the findings are usually nonspecific and mostly help to exclude other pathology, such as an adnexal mass [38,45]. Computed tomography is more accurate but exposes the fetus to radiation [139].

The diagnosis is more frequently missed in pregnant than in nonpregnant patients [138] because:

Leukocytosis, a classic sign of acute appendicitis, occurs physiologically during pregnancy.

Nausea and emesis, common symptoms of acute appendicitis, are also common during pregnancy.

The abdominal pain is sometimes atypically located because the growing gravid uterus displaces the appendix laterally and superiorly.

Other diseases are often confused with appendicitis. The differential diagnosis for appendicitis in pregnancy is shown in Box 2.

Up to one quarter of pregnant women with appendicitis develop appendiceal perforation [140]. Appendiceal displacement predisposes to rapid development of generalized peritonitis after perforation because the omentum is not nearby to contain the infection [26].

Appendicitis during pregnancy requires surgery [141]. Preoperative management during pregnancy is challenging (Table 2). Patients require intravenous hydration and correction of electrolyte abnormalities [142]. Antibiotics are usually administered for uncomplicated appendicitis and are absolutely required for appendicitis complicated by perforation, abscess, or peritonitis [143]. Penicillins (including ampicillin/sulbactam), cephalosporins, clindamycin, and gentamicin are considered safe during pregnancy [83]. Quinolones are not recommended because safer alternatives are available

Box 2. Differential diagnosis of appendicitis during pregnancy

Gynecologic conditions

Ruptured ovarian cyst
Adnexal torsion
Pelvic inflammatory disease or salpingitis
Endometriosis

Obstetric causes

Abruptio placenta
Chorioamnionitis
Endometritis
Fibroid degeneration
Labor (preterm or term)
Viscus perforation after abortion

Other causes

Exacerbation of Crohn's disease
Diverticulitis (right side)
Cholecystitis
Pancreatitis
Mesenteric lymphadenitis
Gastroenteritis
Colon cancer
Intestinal obstruction
Pyelonephritis
Urolithiasis
Hernia (incarcerated inguinal or internal)

[144]. Clindamycin is preferred to metronidazole for anerobic coverage, even though both are category B drugs in pregnancy [145]. Clindamycin and gentamicin is a relatively inexpensive, effective, and safe antibiotic combination. Laparoscopy may be considered during the first 2 trimesters for nonperforated appendicitis or when the diagnosis is uncertain [146]. Appendectomy is recommended even if appendicitis is not evident at surgery [136,138,140]. Maternal mortality from appendicitis has diminished significantly and is currently about 0.1% without perforation but exceeds 4% with perforation [133,134]. Fetal mortality is less than 2% without perforation but exceeds 30% with perforation [133]. Mortality is usually related to delayed diagnosis [27,136,140]. Preterm labor is common, but preterm delivery is unusual [138].

Table 2
Issues in the management of the pregnant woman with appendicitis

Issue	Clinical concern
Preoperative and postoperative fluid management	Amount of fluid administration
Assessment of fetal maturity	Viability if baby delivered
Analgesics	Teratogenicity
Radiologic studies	Fetal radiation exposure
Antibiotics	Fetal teratogenicity
Surgical incision site	Best access to appendix
Laparoscopy versus laparotomy	Best for mother and fetus
Tocolytic therapy	Effects of delayed parturition on fetus
Labor and delivery	Advisability of cesarean section simultaneous with appendectomy

Gastroesophageal reflux and peptic ulcer disease

Gastroesophageal reflux disease (GERD) is manifested by pyrosis, regurgitation, water brash, dyspepsia, hypersalivation, or, rarely, pulmonary symptoms [147]. The incidence of pyrosis approaches 80% during pregnancy [148]. The incidence of GERD is likewise high during pregnancy [149]. This high incidence may relate to gastric compression by the gravid uterus, a hypotonic lower esophageal sphincter (LES), and gastrointestinal dysmotility, believed to be caused by gestational hormones [147,150].

Symptomatic peptic ulcer disease (PUD) is uncommon during pregnancy, and antecedent PUD often improves during pregnancy [147,151]. Nausea, emesis, dyspepsia, and anorexia are so frequent during pregnancy that it may be difficult to diagnose PUD when these symptoms occur [152].

Although the efficacy of modern acid-suppressive drugs has rendered lifestyle modifications less important in the nonpregnant patient with PUD, these modifications remain important in the pregnant patient because of concern about drug teratogenicity [152,153]. Pregnant patients with PUD should avoid caffeine, alcohol, and NSAIDs, although acetaminophen is safe and the cyclo-oxygenase II (COX-II) inhibitors are less gastrotoxic than the nonselective NSAIDs [154]. Patients with GERD should keep the head of the bed elevated at night and should avoid wearing tight belts, recumbency after eating, drinking caffeinated or alcoholic beverages, eating chocolate or fatty foods, and smoking tobacco. Antacids are generally safe for the fetus, but those containing magnesium should be avoided near delivery because they can retard labor and possibly cause neurologic depression in the newborn [155], and those containing sodium bicarbonate should be avoided throughout pregnancy because they may cause fluid overload or metabolic alkalosis [156]. Antacids and dietary measures often suffice during the first trimester for minimally symptomatic disease [2]. Antacids must be administered frequently because of low potency, and frequent administration can cause diarrhea or constipation and electrolyte

or mineral abnormalities. Sucralfate has minimal systemic absorption, but its aluminum content is of concern to the fetus in mothers with renal insufficiency [81]. Misoprostil is an abortifacient and is contraindicated in pregnancy [3]. Histamine$_2$ receptor antagonists are useful in treating GERD and PUD when symptoms are more severe or occur later in pregnancy [2,81]. Ranitidine and famotidine are preferable, because nizatidine is possibly toxic to the fetus [157], and cimetidine has antiandrogenic effects [158]. Proton-pump inhibitors are reserved for refractory, severe, or complicated GERD and PUD. Lansoprazole is safer than omeprazole, and the experience with rabeprazole and pantoprazole during pregnancy is presently insufficient [159]. Metoclopropamide is probably not teratogenic but frequently causes maternal side effects [160]. *Helicobacter pylori* eradication should be deferred until after parturition and lactation because of concern about the fetal safety of clarithromycin and metronidazole [145].

Surgery for GERD is best performed either before or after pregnancy [2,81]. Esophagogastroduodenoscopy is the initial intervention for bleeding from GERD or PUD [151,161], but a hemodynamically unstable patient refractory to endoscopic therapy requires expeditious surgery, because the fetus poorly tolerates maternal hypotension [162,163]. Pregnant PUD patients may also require surgery for gastric outlet obstruction, refractory ulcer, or malignant ulcer [164,165]. Patients in advanced pregnancy should undergo cesarean section just before gastric surgery for gastrointestinal bleeding [162,163]. Gastroesophageal reflux disease and PUD during pregnancy are considered in detail in other articles in this issue.

Upper gastrointestinal bleeding

Upper gastrointestinal bleeding is uncommon but not rare during pregnancy [161]. Although this bleeding is usually painless, bleeding from GERD or PUD may be associated with epigastric or substernal pain. Patients with upper gastrointestinal bleeding that causes hemodynamic instability are approached like nonpregnant patients [166]. A Mallory-Weiss tear is a common reason for hematemesis in the pregnant woman, as is GERD, but PUD should be considered in the presence of abdominal pain and the absence of antecedent retching [167]. The safety and utility of EGD in pregnancy are well validated [97,168]. Esophagogastroduodenoscopy is useful in diagnosing complicated PUD, including gastric outlet obstruction, malignant gastric ulcer, refractory ulcer, and persistently bleeding ulcer [164,165] and in diagnosing complicated GERD, including gastrointestinal bleeding, dysphagia, or Barrett's esophagus.

Intestinal obstruction

Acute intestinal obstruction is the second most common nonobstetric abdominal emergency, with an incidence of 1 in 1500 pregnancies [169,170]. Acute intestinal obstruction may be incidental or secondary to pregnancy.

The exponential recent increase in incidence results from an increased number of abdominal procedures, increased incidence of PID, and increased numbers of pregnancies occurring in older women [189,171]. The obstruction most commonly occurs in the third trimester because of the mechanical effects of the enlarged gravid uterus [172]. In particular, some cases occur at term because of the mechanical effects of fetal head descent and of the abrupt decrease in uterine size at delivery [169,170]. Adhesions, particularly from prior gynecologic surgery or appendectomy, cause 60% to 70% of small bowel obstruction (SBO) during pregnancy [170,171]. Other causes of SBO include neoplasms, particularly ovarian, endometrial, or cervical malignancy; Crohn's disease; external or internal hernias; volvulus; intussusception; EP; prior radiotherapy; and intraluminal gallstones, fecoliths, or other concretions [169,170,173]. Colonic obstruction is caused by adhesions, colon cancer, other neoplasms, diverticulitis, and volvulus [169,170]. Colon cancer is uncommon during pregnancy. When detected during pregnancy, it often presents at an advanced pathologic stage because of delayed diagnosis [4].

Intestinal obstruction classically presents with a symptomatic triad of abdominal pain, emesis, and obstipation [169,170]. The pain may be constant and severe or periodic occurring every 4 to 5 minutes with SBO or every 10 to 15 minutes with colonic obstruction [169–171]. Small bowel obstruction is more painful than colonic obstruction. The pain with SBO may be diffuse and poorly localized and may radiate to the back, flanks, or perineum [170,174]. Abdominal pain is milder with volvulus and intussusception. Intestinal malrotation may produce nonspecific symptoms of mild, crampy pain and nonbilious emesis [175]. Intestinal strangulation may be heralded by guarding and rebound tenderness [169,170]. Emesis occurs more frequently and earlier in small bowel than colonic obstruction [169,170]. Constipation from complete intestinal obstruction is usually severe and unremitting and is associated with abdominal pain [170]. The abdomen is typically distended and tympanitic to percussion [169,170]. Bowel sounds are high-pitched, hypoactive, and tinkling in early intestinal obstruction and are absent in late obstruction.

The approach to intestinal obstruction is the same in pregnancy as in the general population except that the decisions are more urgently required because both the fetus and the intestine are at risk [169,171]. Fetal exposure to radiation is a concern, but supine and upright radiographs are needed to diagnose and monitor intestinal obstruction [170]. Volvulus is suspected when a single bowel loop is grossly dilated. Surgery is recommended for unremitting and complete intestinal obstruction, although medical management is recommended for intermittent or partial obstruction [169,176]. Parenteral fluids are aggressively administered to reverse the fluid and electrolyte deficits caused by emesis and fluid sequestration [169]. Nasogastric suction helps decompress the bowel. Morbidity and mortality from intestinal obstruction are related to diagnostic delays. Maternal

mortality is less than 6% in most series, with fetal mortality of 20% to 30% [169–171]. Maternal mortality is about 13% in colonic volvulus [170].

Diaphragmatic hernia

A congenital or traumatic diaphragmatic hernia is a potentially catastrophic event in pregnancy, with both maternal and fetal mortality from strangulation exceeding 40% [177]. The increased intraabdominal pressure from the enlarged gravid uterus increases the risk of strangulation. Herniorrhaphy is recommended during the first 2 trimesters even for asymptomatic hernias incidentally discovered at surgery [177,178]. Expectant management is recommended for asymptomatic patients during the third trimester, with cesarean section and herniorrhaphy performed when the fetus is sufficiently mature [178]. Cesarean section is performed to avoid increased abdominal pressure during active labor which can cause bowel strangulation. Recurrent diaphragmatic hernia has been described in subsequent pregnancies after herniorrhaphy [178].

Intestinal pseudoobstruction

Adynamic ileus (Ogilvie's syndrome) is characterized by severe abdominal distension detected on physical examination and diffuse intestinal dilatation noted on abdominal roentgenogram. Adynamic ileus is a well described but uncommon complication of cesarean section or vaginal delivery [179,180]. Patients have nausea, emesis, obstipation, and diffuse abdominal pain that typically develops over several days [179]. Patients often have hypoperistalsis. Pyrexia, leukocytosis, and increasing abdominal tenderness may herald gastrointestinal ischemia. Treatment includes nasogastric aspiration, parenteral fluid administration, electrolyte repletion, and rectal tube decompression. The ileus usually spontaneously resolves [179]. Therapeutic options for severe colonic dilatation, with a colonic luminal diameter greater than about 10 cm on abdominal roentgenogram, include colonoscopic decompression; percutaneous radiologic cecostomy [179]; or surgery including cecostomy, cecectomy with diverting ileostomy, or colonic resection when intestinal necrosis supervenes [181]. Parenteral neostigmine administration is contraindicated during pregnancy [179]. Mortality approaches 10% with impending perforation and 70% with cecal perforation [181].

Inflammatory bowel disease

The inflammatory bowel diseases (IBD) of ulcerative colitis (UC) and Crohn's disease (CD) are idiopathic, immunologically mediated disorders that peak in incidence during a woman's reproductive period. The incidence of UC in women under 40 years of age is 40 to 100 in 100,000 and of CD is 2 to 4 in 100,000 [182]. Ulcerative colitis is a colonic disease manifested by

bloody diarrhea, crampy abdominal pain, and pyrexia. Crohn's disease can involve any part of the gastrointestinal tract. It is characterized by diarrhea, abdominal pain, anorexia, pyrexia, and malnutrition. Patients with CD may have fistulas and anorectal disease. Extraintestinal manifestations of IBD include arthritis, uveitis, sclerosing cholangitis, and cutaneous lesions.

Ulcerative colitis does not significantly affect fertility [183]. Crohn's disease, however, decreases fertility because of the effect of ileal inflammation on the nearby oviducts and ovaries or the systemic effects of malnutrition [184]. Inflammatory bowel disease activity is mostly independent of pregnancy [185]. Patients with inactive or mild disease before conception tend to have the same disease activity during pregnancy. Active disease at conception increases the likelihood of active disease during pregnancy and of a poor pregnancy outcome including spontaneous abortion, miscarriage, or stillbirth [186,187]. The onset of CD, and to a lesser extent UC, during pregnancy is associated with increased fetal loss [186,187]. Fetal growth may be retarded in active CD because of maternal malabsorption and malnutrition.

Differentiating the signs and symptoms of IBD from physiologic changes related to pregnancy or from other obstetric, gynecologic or surgical conditions may be difficult. Nausea, emesis, abdominal discomfort, and constipation may be noted during any pregnancy but may also signal active IBD. The differential diagnosis of acute right lower quadrant abdominal pain in a pregnant woman with CD includes disease exacerbation, EP, appendicitis, or adnexal disease. Pyrexia, bloody diarrhea, and weight loss suggest IBD exacerbation.

The diagnostic evaluation is influenced by the pregnancy, but indicated tests should be performed. Laboratory evaluation includes a hemogram, serum chemistry profile, and electrolyte determinations, taking into account the physiologic alterations of late pregnancy including anemia, leukocytosis, and hypoalbuminemia. In particular, an elevated erythrocyte sedimentation rate may reflect physiologic changes during pregnancy rather than active IBD. Flexible sigmoidoscopy is well tolerated in pregnancy without maternal complications or fetal toxicity [161], but diagnostic roentgenographic tests are best deferred until after delivery [186].

The beneficial effects of IBD therapy on the mother and the pregnancy must be weighed against the potential fetal toxicity and teratogenicity (Table 3). Active disease poses greater risk to the fetus than most therapies [188]. Sulfasalazine, 5-aminosalicylates, and corticosteroids seem to be safe [183,186,189]. Methotrexate is not; it is an abortifacient [87,190]. Azathioprine or 6-mercaptopurine (6-MP) can be continued during pregnancy to maintain remission [183,186,191]. The available limited studies in IBD patients, as well as the much larger studies in renal transplant patients, suggest that these drugs are safe during pregnancy [192]. Metronidazole safety during pregnancy is controversial, and metronidazole is probably best avoided during the first trimester [193]. Diphenoxylate

Table 3
Pharmacologic therapy for inflammatory bowel disease during pregnancy

Drug	Recommendation during pregnancy
Corticosteroids	Relatively safe. Concern regarding fetal adrenal function and maternal hypoglycemia.
Sulfasalazine	Relatively safe. Concern about sulfa moiety causing neonatal jaundice.
Mesalamine	Relatively safe.
Metronidazole	Safety is controversial. Best avoided during the first trimester.
Ciprofloxacin	Use with caution, especially during the first trimester.
Methotrexate	Contraindicated. Teratogen/abortifacient.
6MP, Azathioprine	Avoid starting after conception. Might cause IUGR.
Remicade (anti-TNF)	Insufficient data, avoid for now.
Loperamide	Relatively safe.
Diphenoxylate	Avoid, possible teratogen.

Abbreviations: 6MP, 6 mercaptopurine; TNF, tumor necrosis factor; IUGR, intrauterine growth retardation.

should be avoided [191]. Emergency surgery for toxic megacolon, intestinal obstruction, or massive bleeding should be done expeditiously, whereas elective surgery, such as fistulectomy, should be performed during the second trimester or postpartum [187,191,194]. Severe perianal CD may necessitate cesarean section, because an episiotomy during vaginal delivery may exacerbate perianal disease [195].

Irritable bowel syndrome

The irritable bowel syndrome (IBS) is most common in younger women. The pathogenesis is poorly defined. Both intestinal motor and sensory abnormalities, particularly hyperalgesia, have been described [17]. Irritable bowel syndrome is diagnosed, according to the Rome II criteria, by the presence of both abdominal pain and disordered defecation for at least 3 months, not necessarily continuous, during the past year in the absence of demonstrable organic disease [196]. Endoscopic, radiologic, and histologic studies reveal no evident organic disease. Young women typically have diarrhea-predominant IBS but sometimes have predominantly constipation or alternating diarrhea and constipation. Abdominal bloating and distension are common symptoms.

Little data exist concerning the effect of pregnancy on IBS [197]. Gestational hormones, particularly progesterone, may exacerbate the symptoms of IBS [198]. Presumed IBS in the absence of warning signs or symptoms, such as rectal bleeding, should not require invasive tests, such as sigmoidoscopy, during pregnancy. Contrariwise, signs and symptoms of organic disease, such as rectal bleeding or involuntary weight loss, should not be attributed to IBS without proper evaluation. In particular, sigmoidoscopy is indicated for nonhemorrhoidal rectal bleeding during pregnancy [46]. Pharmacologic therapy for IBS is not well validated in the general population, and IBS is best treated during pregnancy by dietary

modification and behavioral therapy for severe symptoms rather than by systemic drugs [199]. Patients with diarrhea-predominant IBS may benefit from elimination of foods from the diet that precipitate diarrhea, such as alcohol, caffeinated beverages, poorly digestible sugars, and fatty foods. Significant calcium intake is obligatory in pregnancy, but patients may benefit from lactase supplements when ingesting dairy products. Dietary fiber and fluid ingestion may improve constipation-predominant IBS. Irritable bowel syndrome should not affect fertility and pregnancy outcome in the absence of nutritional deficiencies or concomitant disorders, but this subject is unstudied [197].

Pancreatobiliary disease

Acute pancreatitis

Acute pancreatitis has been reported in 0.1% to 1% of pregnancies, most commonly occurring during the third trimester and postpartum [200,201]. Gallstones cause more than 70% of cases [202]. Pancreatitis secondary to alcoholism is relatively uncommon during pregnancy [200,203]. Other causes include drugs, abdominal surgery, trauma, hyperparathyroidism, hyperlipidemia, vasculitis, and infections such as mumps and mononucleosis [200,203]. Some cases are idiopathic. Pancreatitis can complicate the course of thrombotic thrombocytopenic purpura (TTP) during pregnancy [204–206].

Pregnancy does not cause or significantly alter the clinical presentation of acute pancreatitis [200,203,205]. Epigastric pain is the most common complaint. The pain may radiate to the back, shoulders, or flanks [200,203]. Nausea, emesis, and pyrexia frequently occur [205]. Signs include mid-abdominal tenderness with occasional rebound tenderness, abdominal guarding, hypoactive bowel sounds, abdominal distension, and increased tympany [200,205]. Severe cases are associated with shock and ascites and with the Grey Turner's or Cullen's signs from retroperitoneal bleeding [200,205].

Acute pancreatitis is diagnosed by the clinical presentation, laboratory tests, and radiologic examinations. Serum amylase and lipase are reliable markers of acute pancreatitis during pregnancy because the lipase level is unchanged during pregnancy, and the amylase level is normally only mildly elevated during pregnancy [207]. Hyperamylasemia may also occur in diabetic ketoacidosis, renal failure, bowel perforation, or bowel obstruction, but the serum lipase and amylase-to-creatinine clearance ratio are normal in these conditions and are elevated in acute pancreatitis [208]. Hypertrigylceridemia can falsely lower serum amylase levels in pancreatitis, but the lipase level remains elevated [208]. Abdominal ultrasonography is used to detect cholelithiasis and bile duct dilatation, but endoscopic ultrasonography is required to detect choledocholithiasis reliably [209]. Abdominal ultrasonography is useful in gauging pancreatic inflammation in thin

patients with mild to moderate acute pancreatitis, but CT scanning is used for severe pancreatitis to delineate areas of pancreatic necrosis [205,210].

Acute pancreatitis in pregnancy is usually mild and responds to medical therapy including taking nothing by mouth, intravenous fluid administration, gastric acid suppression, analgesia, and possibly nasogastric suction [202,205,211,212]. Meperidine is the traditional choice for analgesia because it does not cause contraction of the sphincter of Oddi [213]. Meperidine seems to be relatively safe for short-term use during pregnancy [214]. Severe pancreatitis with a phlegmon, abscess, sepsis, or hemorrhage necessitates monitoring in an intensive care unit, antibiotic therapy, total parenteral nutrition, and possible radiologic aspiration or surgical débridement [205,212,215]. Large and persistent pancreatic pseudocysts require endoscopic or radiologic drainage or surgery [205,211,215,216]. Pregnancy should not delay CT-guided aspiration or surgery [215]. Endoscopic sphincterotomy can be performed during pregnancy with minimal fetal radiation exposure [217].

Maternal mortality is low in uncomplicated pancreatitis but exceeds 10% in complicated pancreatitis [205,212]. Pancreatitis during the first trimester is associated with fetal wastage and during the third trimester is associated with premature labor [203,218].

Cholelithiasis and cholecystitis

Pregnancy promotes bile lithogenicity and sludge formation because estrogen increases cholesterol synthesis and progesterone impairs gallbladder motility [219,220]. In a large ultrasound study in Chile, 12% of pregnant women had cholelithiasis versus 1.3% of nonpregnant controls [221]. An Italian study reported an even higher incidence of cholelithiasis [212]. Pregnancy, however, does not seem to increase the severity of gallstone complications.

Most gallstones are asymptomatic during pregnancy [212,222]. Symptoms of gallstone disease during pregnancy are the same as in other patients [221,222]. The usual initial symptom is biliary colic that is located in the epigastrium or right upper quadrant and may radiate to the back, flank, or shoulders [223]. The pain can occur spontaneously or be induced by eating a fatty meal. The pain typically lasts 1 to several hours. Diaphoresis, nausea, and emesis are common. Physical examination is unremarkable, other than occasional right upper quadrant tenderness. About one third of patients with biliary colic will experience no additional bouts during the following 2 years, but the natural history of the remaining patients is variable [223,224]. Complications of cholelithiasis include cholecystitis, choledocholithiasis, jaundice, ascending cholangitis, biliary stricture, sepsis, abscess, empyema, gallbladder perforation, and gallstone pancreatitis. Pregnancy does not increase the frequency of these complications [212,222].

Acute cholecystitis is a chemical inflammation usually caused by cystic duct obstruction and supersaturated bile. It is the third most common nonobstetric surgical emergency during pregnancy. The incidence of 1 to 8 cases per 10,000 pregnancies is much less than the prevalence of gallstones during pregnancy [205,206,223]. As in biliary colic, the pain is located in the epigastrium and right upper abdominal quadrant, but it is usually more severe and prolonged [26,225]. Other clinical findings include nausea, emesis, pyrexia, tachycardia, right-sided subcostal tenderness, and Murphy's sign [225,226]. Leukocytosis is common. Serum liver function tests and amylase may be mildly abnormal. Jaundice suggests possible choledocholithiasis, and pronounced hyperamylasemia indicates gallstone pancreatitis. The differential diagnosis includes viral hepatitis, pneumonia, appendicitis, peptic ulcer disease, pyelonephritis, cholestasis of pregnancy, acute fatty liver of pregnancy (AFLP), HELLP syndrome, and shingles [26,215,226].

Patients with recurrent biliary colic or acute cholecystitis usually undergo cholecystectomy [128,221,226–228]. Preoperative management includes discontinuing oral intake, administration of intravenous fluids, analgesia, and, usually, antibiotics [220,224]. Ampicillin, cephalosporins, and clindamycin are relatively safe antibiotics during pregnancy [145,226]. Abdominal surgery is best performed during the second trimester; cholecystectomy during the first trimester is associated with fetal wastage and during the third trimester is associated with premature labor [128,226,228]. Cholecystectomy may be deferred in selected patients with acute cholecystitis during pregnancy but has become more acceptable during the first and third trimesters because of advances in maternal and fetal monitoring, advances in laparoscopic surgery, and realization of the detrimental effects of delayed surgery [128,228,229]. Intraoperative cholangiography is performed only for strong indications to avoid radiation teratogenicity. Laparoscopic cholecystectomy is safe during pregnancy [128,229,230]. Tocolysis may be necessary during cholecystectomy in the third trimester [99,128]. Both maternal and fetal mortality from acute cholecystitis is less than 5% during pregnancy [222,229,231].

Choledocholithiasis

The prevalence of asymptomatic choledocholithiasis during pregnancy is uncertain because of the insensitivity of transabdominal ultrasound [38,166]. Symptomatic choledocholithiasis is uncommon during pregnancy [26, 166,167].

Choledocholithiasis can cause abdominal pressure or jaundice [225]. Choledocholithiasis can produce biliary pancreatitis and ascending cholangitis [205,206]. Ascending cholangitis is manifested by pyrexia, chills, abdominal pain, and leukocytosis. Gallstone pancreatitis is heralded by pyrexia, nausea, and severe abdominal pain. Endoscopic ultrasound is safe

in pregnancy and is sensitive in detecting choledocholithiasis [209,232]. Patients with choledocholithiasis and gallstone pancreatitis should undergo endoscopic retrograde cholangiography (ERCP) with sphincterotomy [233]. The safety of ERCP during pregnancy is discussed in another article in this issue. Endoscopic retrograde cholangiography can be performed with little fetal radiation exposure and avoidance of pancreatic duct injection [217,234]. These patients should undergo cholecystectomy postpartum [205] but can undergo biliary surgery during pregnancy with acceptable maternal and fetal mortality [235]. Choledochal perforation, a rare complication, is usually managed by endoscopic biliary stent placement followed by biliary surgery [236].

Choledochal cysts and neoplasms

Choledochal cysts are rare and are usually diagnosed before the age of 10 years. They usually produce a diagnostic triad of abdominal pain, jaundice, and a palpable abdominal mass [237]. Choledochal cysts rarely present during pregnancy. The usual symptoms during pregnancy are abdominal pain and jaundice [238–241]. Pregnancy can exacerbate these symptoms because of hepatobiliary compression by the enlarged gravid uterus [242]. Increasing pain suggests cyst rupture or concomitant pancreatitis [238,239]. The diagnosis can be made by abdominal ultrasound, although cholangiography is sometimes necessary [243]. Management of choledochal cysts in pregnancy is evolving. Surgery is generally recommended because of the risk of recurrent cholangitis and malignant degeneration. The standard surgery is cystectomy, cholecystectomy, and reconstitution of biliary-intestinal flow by either a Roux-en-Y hepaticojejunostomy or choledochojejunostomy [237,238,241]. Medical management, including antibiotics and temporary percutaneous or endoscopic drainage, may suffice until delivery [239, 241,243,244]. Cesarean section is usually necessary because normal labor can cause cyst enlargement or rupture [241,243].

Liver disease during pregnancy

Common liver diseases incidental to pregnancy

Various liver abnormalities occur during pregnancy, but severe liver disease occurs in less than 1 in 1000 pregnancies [245–247]. Jaundice during pregnancy includes pregnancy-related and unrelated causes. The differential diagnosis for jaundice in the first and second trimesters of pregnancy includes:

Viral hepatitis
Gallstone disease (acute cholecystitis, choledocholithiasis, ascending cholangitis, biliary stricture, or gallstone pancreatitis)
Drug hepatotoxicity

In the third trimester, the differential diagnosis includes

Intrahepatic cholestasis of pregnancy
Viral hepatitis
Gallstone disease (acute cholecystitis, choledocholithiasis, ascending cholangitis, biliary stricture, or gallstone pancreatitis)
Drug hepatotoxicity
Preeclampsia and eclampsia (with minimal jaundice)
Acute fatty liver of pregnancy
HELLP syndrome
Budd-Chiari syndrome (with minimal jaundice)

Acute viral hepatitis is the most common cause [245–247]. Viral hepatitis generally presents similarly in pregnancy as in the nonpregnant state. Acute viral hepatitis may cause anorexia, nausea, malaise, and abdominal discomfort from acute hepatic enlargement and stretch of Glisson's capsule. Hepatitis E, however, is much more severe and has a high mortality rate during pregnancy [248]. Hepatitis E is rare in the United States. Maternal hepatitis B may be transmitted in utero or intrapartum to the neonate, and neonatal infection often becomes chronic [249]. Infants born to infected mothers should receive passive immunization with hepatitis B hyperimmune globulin (HBIG) and active immunization with hepatitis B vaccine [250].

Chronic liver disease that predated conception, such as chronic viral hepatitis, may first manifest during pregnancy. Autoimmune hepatitis can be exacerbated by pregnancy and is associated with increased fetal mortality [245,247].

Preeclampsia and eclampsia

Preeclampsia complicates 3% to 6% of pregnancies. Preeclampsia is defined by the triad of hypertension, proteinuria of more than 300 mg/24 hours, and peripheral edema. Patients have a blood pressure of at least 140/90 mm Hg or an increase of 30 mm Hg in systolic or 15 mm Hg in diastolic blood pressure from first-trimester measurements [251,252]. The blood pressure must be elevated at two readings taken at least 6 hours apart. The preeclampsia is severe when proteinuria exceeds 1 g/24 hours or the blood pressure is more than 160/110 mm Hg [252,253]. Severe preeclampsia may cause oliguria, jaundice, thrombocytopenia, pulmonary edema, and neurologic abnormalities of headaches or visual disturbances [245,251,252]. In eclampsia, seizures occur in addition to the other symptoms. The pathogenesis of preeclampsia and eclampsia is under intense investigation: exaggerated vascular endothelial reactivity to angiotensin II or decreased synthesis of vasodilators, such as nitric oxide and prostacyclin, may promote hypertension and end-organ damage [253–255]. Preeclampsia usually occurs in younger primiparous or older multiparous women. Other risk factors include diabetes mellitus, antiphospholipid antibody syndrome,

hydatiform mole, and fetal hydrops [245,251–253]. Preeclampsia usually presents later in pregnancy but may present earlier or postpartum.

About 10% of patients with severe preeclampsia have hepatic dysfunction [256,257]. Pathologic examination of a liver biopsy usually demonstrates sinusoidal fibrin deposition and periportal hemorrhage and occasionally demonstrates hepatocellular necrosis [252,258]. Symptoms include nausea, emesis, and epigastric or right upper quadrant pain that may radiate to the right shoulder [245,246,258]. Severe pain may herald hepatic infarction, hemorrhage, or rupture [246,258]. Right upper quadrant tenderness is common. Laboratory abnormalities include mild hyperbilirubinemia, marked serum transaminase elevations, thrombocytopenia, and normal coagulation parameters [245,246,252]. Hepatic involvement is often accompanied by hemolysis, thrombocytopenia, renal dysfunction, altered sensorium, eclampsia, or hepatic decompensation [246,253,259,260].

Preeclampsia and eclampsia are a leading cause of maternal mortality. Eclampsia is an obstetric emergency that can progress rapidly to cause maternal and fetal mortality [245,251,252]. More than 20% of women without prenatal care die [251,252,259,260]. Maternal mortality from severe preeclampsia is less than 1% in tertiary hospitals, and fetal mortality is less than 5% in deliveries after 34 weeks of gestation [251,252] but is much higher in deliveries during the second trimester [251,260,261]. Patients who present near term with mild preeclampsia have minimally increased mortality [251,252,260]. Maternal mortality is most commonly from neurologic involvement, but about 15% of the mortality is attributable to hepatic complications of liver failure, hemorrhage, or infarction [246, 252,260].

Hemolysis, elevated liver function tests and low platelet count syndrome

The HELLP syndrome [257] occurs in 1 to 6 of 1000 pregnancies [245,246]. The presentation is somewhat variable, but typical findings include hemolytic anemia, thrombocytopenia, and liver function test abnormalities [257,262,263]. Laboratory criteria for HELLP syndrome are:

Peripheral smear: microangiopathic hemolysis (schistocytes)
Platelets: fewer than 50,000/mm^3
Serum total bilirubin: greater than 1.2 mg / 100 mL
Serum lactate dehydrogenase: higher than 600 U/L
Serum aspartate aminotransferase: higher than 70 U/L

Patients typically present in the third trimester or postpartum [245, 246,262,263].

Patients usually have epigastric or right upper quadrant pain [246,262,263]. Other symptoms include right shoulder pain, nausea, emesis, malaise, headache, visual changes, bleeding, and jaundice [257,262,263]. Physical examination may reveal right upper quadrant abdominal tender-

ness and peripheral edema [262,263]. Patients usually have hypertension and significant proteinuria [263]. Liver biopsy abnormalities correlate poorly with clinical features or liver function test abnormalities [246,257]. The differential diagnosis includes severe preeclampsia, AFLP, systemic lupus erythematosus, thrombotic thrombocytopenic purpura, and hemolytic uremic syndrome [246,262,263]. The abdominal pain may also simulate acute viral hepatitis, cholecystitis, appendicitis, pyelonephritis, nephrolithiasis, and various obstetric disorders.

The HELLP syndrome is a medical emergency, with a maternal mortality rate of 1% to 2% and a fetal mortality rate of 10% to 35% that depends on the gestational age at delivery [246,262–264]. It is associated with intrauterine growth retardation and prematurity [145,246,262]. Patients with HELLP syndrome can develop placental abruption, DIC, spontaneous hemorrhage, acute renal failure, pulmonary edema, and hepatic hematoma or rupture [262–265].

Management of preeclampsia, eclampsia, and HELLP syndrome

Preeclampsia, eclampsia, and HELLP syndrome are related disorders with shared pathogenic, pathologic, and clinical features [245,246,263,266]. Indeed, 10% to 28% of patients with preeclampsia or eclampsia develop the HELLP syndrome [246,257,261,263,266]. Hypertension is universal with preeclampsia or eclampsia, as are hemolytic anemia and thrombocytopenia with HELLP, but these features may be part of either syndrome. The management is tailored to the clinical manifestations as well as the diagnosis. Patients with mild preeclampsia can be managed at home, but patients with severe hypertension, eclampsia, or HELLP should be managed in an intensive care unit, preferably at a tertiary medical center [262–264].

Delivery is the definitive therapy [245,246,260,262,264]. If these disorders manifest after 34 weeks of gestation and after documentation of fetal lung maturity, the fetus should be promptly delivered [246,262,264]. Vaginal delivery can usually be performed, but cesarean section is sometimes necessary, with use of general anesthesia and preoperative platelet transfusions [262,264]. Laboratory abnormalities usually peak during the first 48 hours postpartum, and the patient should remain in the ICU during this time and receive platelet transfusions or factor replacement as necessary for DIC [246,262,264]. The platelet count normalizes within 1 week of delivery [262]. Hypertension is managed aggressively with parenteral agents if necessary [261,262,264]. Magnesium is administered to prevent seizures. Specific treatment is administered for renal insufficiency or pulmonary edema. Plasmapheresis has been used for the HELLP syndrome, when thrombocytopenia and organ dysfunction persist for more than 72 hours postpartum [246,262]. Management of these syndromes before 34 weeks of gestation is problematic and controversial [210,263,264,266]. Delivery

can be deferred for several days if maternal seizures, bleeding, or other complications or fetal distress do not occur [245,246,261]. Corticosteroids may be administered to accelerate fetal lung maturity [246,261].

Hepatic hemorrhage and rupture

Hepatic rupture is a rare, but catastrophic, complication of pregnancy resulting from progressive hepatic bleeding and expansion under Glisson's capsule [246,265]. The main causes are preeclampsia or eclampsia with DIC, or the HELLP syndrome [259,261,264,265–267]. One percent or more of patients with the HELLP syndrome have a subcapsular hematoma [264,268]. Other causes of hepatic hemorrhage are hepatic trauma, hepatic abscess, hepatocellular carcinoma, hepatic metastases, ruptured hemangiomas, hepatic amyloidosis, hepatic lymphoma, and cocaine use [265,267–272]. Idiopathic cases can occur [273]. Patients are usually multiparous [264,265,268]. Hepatic rupture usually involves the right lobe and occurs just before delivery or postpartum [264,267,268].

Pain commonly occurs in the right upper quadrant, epigastrium, or right shoulder [264,267,268]. Signs include hepatomegaly, hepatic tenderness, and rebound tenderness with peritonitis [246,262,264,271]. Laboratory findings may reflect HELLP or DIC if they are present but are otherwise nonspecific. Rupture can present as a clinical triad of preeclampsia or eclampsia, abdominal pain, and hypotension [268,271,272]. Pathologic examination of the liver reveals sinusoidal fibrin deposition and extensive, primarily periportal, hemorrhage [246,260,262,268].

The differential diagnosis of an unruptured hepatic hematoma includes AFLP, placental abruption with DIC, acute cholecystitis, uterine rupture, and thrombotic thrombocytopenic purpura [262,264,267,268]. Hepatic subcapsular hematoma can be diagnosed by ultrasonography, MR imaging, or nuclear scan, but CT scanning is the most sensitive and specific imaging test [267–269,272]. Paracentesis can document blood in the peritoneal cavity but should not delay definitive management [269,272].

The maternal and perinatal mortality from hepatic hemorrhage has decreased substantially during the last 30 years but remains more than 30% [262,264,274–276]. The patient should be hemodynamically stabilized, and coagulopathy should be corrected preoperatively [262,264,274,275]. Conservative management of an unruptured subcapsular hematoma with frequent serial CT scans and close clinical monitoring may sometimes be indicated [262,264,274,276]. Treatment options include evacuation of the hematoma with packing and drainage, angiographic embolization, hepatic artery ligation, or hepatic resection. The mortality is highest with hepatic lobectomy and lowest with transarterial embolization of a bleeding hepatic artery identified at angiography [262,264,274–276]. Hepatic rupture is a medical emergency, because the fetus poorly tolerates concomitant shock. Patients with hepatic hemorrhage usually have uneventful subsequent

pregnancies, although a few reported patients had recurrent hepatic hemorrhage [275,277,278].

Acute fatty liver of pregnancy

Acute fatty liver of pregnancy is a rare but potentially devastating disease characterized by hepatic microvesicular steatosis associated with mitochondrial dysfunction. It usually manifests in the third trimester or immediately postpartum but can present earlier [245,246,260,279]. It occurs in about 1.0 of 10,000 pregnancies [245,246,280]. It is more common in primiparas [245,279,281,282]. It is related to an autosomally inherited mutation that causes deficiency of the long chain 3-hydroxyacyl coenzymeA dehydrogenase, a fatty acid beta-oxidation enzyme [283].

The initial symptoms, including anorexia, nausea, emesis, malaise, fatigue, and headache, are nonspecific [246,260,279,280]. About half of the patients have epigastric or right upper quadrant pain, and about half have hypertension [280–282]. Physical examination may reveal hepatic tenderness, usually without hepatomegaly [279–281]. Serum transaminase and bilirubin levels are variably elevated. Jaundice usually manifests later in the course of the illness or after delivery. Other laboratory abnormalities include leukocytosis, hypofibrinogenemia, increased fibrin-split products, prolonged prothrombin time, increased serum ammonia level, increased serum uric acid level, and increased blood urea nitrogen and serum creatinine levels [260,280–282].

The differential diagnosis is broad. Acute fatty liver of pregnancy differs from severe acute viral hepatitis in that serum transaminase levels in AFLP rarely exceed 1000 U/L, and viral serologic tests are negative [245,252,260,276]. Liver biopsy is usually diagnostic but is not indicated for suspected AFLP unless the presentation is atypical or postpartum jaundice is prolonged [245,281,284]. Hepatic pathology reveals intracytoplasmic microsteatosis in hepatocytes, as highlighted by the Sudan or oil red O stains, preservation of hepatic architecture, and isolated foci of inflammatory and necrotic cells [245,281,282,284]. Sinusoidal deposition of fibrin is usually not present in AFLP but is usually present in preeclampsia and eclampsia [281,282,284,285]. Acute hepatitis is associated with a much greater inflammatory infiltrate and hepatocyte necrosis [245,281,282]. Hepatic imaging studies primarily help to exclude other disorders or to detect hepatic hemorrhage [279,280,286]. Acute fatty liver of pregnancy may be difficult to distinguish from HELLP syndrome and preeclampsia or eclampsia with DIC [262,282,285]. Fortunately, the definitive treatment for all these disorders is fetal delivery. Complications include pulmonary edema, pancreatitis, diabetes insipidus, DIC, seizures, coma, and hepatic failure manifested by jaundice, encephalopathy, ascites, or variceal bleeding [279–282]. The complications may require specific therapy: hepatic encephalopathy with lactulose, renal failure with hemodialysis, gastrointestinal bleeding

with blood transfusions and endoscopic therapy, DIC with blood products, and diabetes insipidus with desmopressin (DDAVP). Most patients improve clinically and biochemically within 3 days after delivery [279,280]. Hepatic transplantation has been performed for AFLP but is controversial [281,282,287,288]. The maternal and fetal mortality of AFLP have decreased sharply during the last 2 decades to less than 15% [246,280,281,289]. Acute fatty liver of pregnancy rarely recurs in a subsequent pregnancy [281].

Budd-Chiari syndrome

The Budd-Chiari syndrome refers to hepatic vein thrombosis or occlusion that increases the hepatic sinusoidal pressure and can lead to portal hypertension or hepatic necrosis [246,260,290,291]. Many cases are secondary to congenital vascular anomalies or hypercoagulopathies. Acute and chronic presentations occur. The characteristic clinical triad is abdominal pain, hepatomegaly, and ascites [290,291]. Budd-Chiari syndrome is rare in pregnancy even though pregnancy tends to promote Budd-Chiari syndrome [245,290,291]. Budd-Chiari syndrome usually presents in the last trimester or within several months postpartum [245,290]. The serum bilirubin and alkaline phosphatase levels are typically moderately elevated, with normal to mildly elevated serum transaminase levels. Budd-Chiari syndrome is diagnosed by pulsed Doppler ultrasound, hepatic venography, or magnetic resonance angiography [290–292]. Liver biopsy may reveal central venous congestion. The definitive therapy is liver transplantation. Death otherwise occurs within a decade after diagnosis [290–292]. Selective thrombolytic therapy and surgical or radiologic remedy of portal hypertension for intractable ascites or variceal bleeding have also been described [290,291]. Patients have had subsequent successful pregnancies after undergoing liver transplantation for Budd-Chiari syndrome during the puerperium [292,293].

Hepatic cysts, abscesses, and tumors

Hepatic adenomas, hemangiomas, and nodular hyperplastic lesions are usually asymptomatic and detected incidentally during obstetric ultrasound [38,167,209]. These hepatic lesions can, however, grow during pregnancy, possibly because of estrogen stimulation, and occasionally cause hepatic hemorrhage, cyst rupture, or biliary obstruction that often manifest with abdominal pain [294–296]. Surgical intervention may be necessary [294–296]. Giant hepatic hemangiomas may cause hemolysis [297]. Hepatic cysts may be isolated or associated with hepatic polycystic disease, malignancy, or amebic or ecchinococcal infection [294,298–300]. Pyogenic liver abscesses during pregnancy arise from ascending cholangitis, appendicitis, or diverticulitis [294,296,301]. Both surgery and antibiotics are usually indicated.

Hepatocellular carcinoma (HCC) usually occurs in cirrhosis secondary to chronic viral hepatitis, hemochromatosis, or alcoholism. Less than 50 cases

have been reported during pregnancy [294,296,299,300]. The poor prognosis during pregnancy may result from delayed diagnosis [299,300]. Screening high-risk patients by serum alpha-fetoprotein determination and abdominal ultrasound can detect HCC earlier [294,302]. The fibromellar variant of HCC, typically found in younger women, has a better prognosis [303]. Colon cancer metastatic to the liver can occur during pregnancy [4,304].

Acute intermittent porphyria

The porphyrias are rare diseases caused by deficiency of various heme biosynthetic enzymes that result in accumulation of toxic porphyrin precursors. Acute intermittent porphyria (AIP) is the most common hepatic porphyria, with a frequency of about 1 in 10,000 people [305]. Patients have porphobilinogen deaminase deficiency. Acute intermittent porphyria is transmitted as an autosomal trait with incomplete penetrance [305,306] that is strongly affected by environmental factors, including diet, drugs, medical illness, and female sex hormone levels, with more severe symptoms in women and with symptomatic exacerbations linked to menstruation, pregnancy, and oral contraceptive administration [167,306–308]. About one third of patients first present during pregnancy or immediately postpartum [308,309]. Hyperemesis gravidarum is a common precipitant [23,309].

Diffuse abdominal pain is common [305,306,308–310]. Other symptoms include vomiting, constipation, and neuropsychiatric abnormalities [306,308]. Autonomic abnormalities can cause tachycardia, hypertension, or ileus. Unlike other porphyrias, AIP has no dermatologic manifestations.

Acute intermittent porphyria should be considered in any pregnant patient with abdominal pain and a puzzling diagnostic evaluation. The differential includes preeclampsia or eclampsia, among other diseases [245,253]. Increased urinary levels of porphobilinogen and delta-aminolevulinic acid are diagnostic [306,308]. Management includes avoidance of precipitating drugs, avoidance of fasting, and possible administration of hematin or parenteral glucose [306,308]. The maternal mortality is less than 10%, with a fetal wastage rate of 13% and frequent low birth weight infants [306–309]. Genetic counseling is recommended [305,306].

Renal disorders

Urinary tract disorders

Physiologic renal alterations, including hydronephrosis or hydroureter, occur in 70% to 90% of pregnancies probably because of diminished muscle tone in the urinary tract from elevated progesterone levels and mechanical obstruction from fetal compression, which is usually more prominent on the right ureter [310,311]. These alterations are most pronounced during the late second and early third trimesters [311,312], during which period the risk of

acute pyelonephritis is greatest [310,312]. Physiologic ureteral dilation during pregnancy must be differentiated from pathologic dilation caused by a stone or stricture. Hydronephrosis in pregnancy is usually asymptomatic, but patients occasionally develop positional abdominal discomfort and, rarely, develop functional ureteral obstruction necessitating ureteral stents or progress to ureteral rupture [247,312,313].

Bacteriuria and cystitis

Asymptomatic bacteriuria (ASB), defined as more than 10^5 microorganisms per mm^3 in a urine specimen, occurs in about 7% of pregnancies [310,314]. The incidence is similar in age-matched nonpregnant women, but pregnant women have a much higher risk of complications probably because of urinary stasis and mildly decreased mucosal immunity during pregnancy [36,315]. Acute cystitis occurs in about 2% of pregnancies [310,314]. Symptoms include urinary frequency, urgency, and suprapubic discomfort, but many cases are asymptomatic [314,315].

Asymptomatic bacteriuria is aggressively diagnosed, treated, and monitored during pregnancy to prevent acute pyelonephritis. Twenty-five percent to 40% of pregnant women with untreated ASB develop acute pyelonephritis [310,314,315]. Urinalysis should be performed at a woman's first prenatal visit. Cystitis requires 1 week of therapy, but the duration of treatment for ASB is uncertain during pregnancy [314,316]. The most common microorganism in ASB, cystitis, and pyelonephritis is *Escherichia coli* [319,314,315]. Cephalosporins, sulfonamides, or nitrofurantoin are the recommended therapy during pregnancy [145,310,314]. Sulfonamides should not be used near to term because of the risk of fetal kernicterus, and quinolones are not recommended during pregnancy [145,314,315]. Ampicillin is no longer recommended for ASB or cystitis because of bacterial resistance [310,314]. Urinalysis should be repeated after treatment. About 30% of patients require retreatment [36,317]. Antibiotic prophylaxis may be considered in patients near term with recurrent infection or with cystitis caused by Streptococcus Group B organisms [314,315].

Acute pyelonephritis occurs in 1% to 2% of pregnancies [310,314]. It usually results from ASB or acute cystitis [36,310,314]. Risk factors include nephrolithiasis, recurrent lower urinary tract infection, diabetes mellitus, sickle cell anemia, and congenital ureteral abnormalities [36,310,315]. Symptoms during pregnancy are similar to those in the general population and include pyrexia, chills, nausea, emesis, and flank pain. The pain may radiate to the abdomen or pelvis and may cause costovertebral tenderness. Urine and blood cultures should be obtained, but the initial therapy is usually empiric [317,318]. Broad-spectrum cephalosporins such as ceftriaxone are often used [317,318]. Antibiotics are initially administered parenterally and changed to oral therapy after the patient clinically improves [201]. Recurrence or relapse is usually caused by incomplete eradication

of a lower genitourinary tract infection or anatomic urinary tract abnormalities [314,315,317]. Renal ultrasound is performed in patients who fail to respond clinically within 3 days or who have recurrent infection [252,315]. Complications of pyelonephritis include septicemia, shock, pulmonary edema, adult respiratory distress syndrome (ARDS), recurrent infection, renal abscess, and renal insufficiency [252,310,314,315,317]. Pyelonephritis is associated with premature labor and delivery [310,314].

Urolithiasis

Symptomatic urolithiasis is documented in less than 5 in 1000 pregnancies but accounts for most nonobstetric hospitalizations during gestation [319,320]. About half of kidney stones in pregnancy are caused by hypercalcuria, including about 10% secondary to primary hyperparathyroidism [319,320]. The remainder are caused by uric acid, struvite, or cystine or are idiopathic [320,321].

Patients usually present during the second or third trimester. Symptoms include abdominal or flank pain, gross hematuria, nausea, emesis, urinary urgency, and urinary frequency [320,322]. Abdominal pain typically radiates from the back or abdomen into the groin [319]. The diagnosis is challenging during pregnancy [319–321] because:

Symptomatic urolithiasis is difficult to differentiate from painful hydronephrosis without urolithiasis.
Microscopic or gross hematuria commonly occurs in normal pregnancy.
Diagnostic fluoroscopy is relatively contraindicated because of fetal risks.
Concomitant infection frequently occurs.

Right-sided renal colic may be difficult to differentiate from perforated duodenal ulcer, acute cholecystitis, and appendicitis.

Ultrasonography is the standard initial diagnostic test during pregnancy [322,323]. Accuracy is improved by use of transvaginal probes, ureteral jets (Doppler), and intrarenal resistance indices [322–324]. Magnetic resonance urography, with strongly T2-weighted sequences, may demonstrate obstruction without intravenous contrast [323]. Fluoroscopy with contrast urography is sometimes necessary in ambiguous cases, when the potential benefits from the diagnostic information outweigh the risks from radiation [309,322,325]. Radiation exposure is usually less than 0.2 rads, posing little fetal risk during the last two trimesters [325].

Treatment includes aggressive hydration and analgesia and antibiotics for concomitant infection. Most renal stones spontaneously pass during pregnancy, but conservative management entails the risk of renal colic inducing premature labor [319,321,322]. Obstruction, infection, or sepsis in pregnancy, as in the nonpregnant state, requires retrograde or percutaneous ureteral stent placement or percutaneous nephrostomy [319,321,322,325]. Stents are deployed using local anesthesia with ultrasound guidance to

ensure fetal safety [319]. Stents are generally well tolerated. Ureteroscopy with stone manipulation by laser lithotripsy has been described [322,325]. Surgery is reserved for refractory cases. Extracorporeal shock-wave lithotripsy (ECSWL) has been reported but is relatively contraindicated during pregnancy [319,322].

Genitourinary cancers

Several cases of renal cell or bladder cancer have been reported during pregnancy. Renal cell cancer should be considered in pregnant women with refractory or recurrent urinary symptoms, flank pain, or a palpable flank mass [326]. Ultrasound is usually diagnostic.

Abdominal pain caused by systemic diseases

Vascular and hematologic disease

Abdominal vascular catastrophes during pregnancy include aneurysm rupture, mesenteric venous thrombosis, hepatic hemorrhage or rupture, and Budd-Chiari syndrome. Splenic artery aneurysm rupture is associated with pregnancy, possibly because of the effects of gestational hormones on the elastic properties of the arterial wall [327]. Patients present in shock with left upper quadrant abdominal pain [328]. The diagnosis is suggested by demonstration of a rim of calcification from the aneurysm on plain abdominal roentgenogram and is confirmed by abdominal CT scanning or angiography. Treatment consists of fluid resuscitation and immediate surgery, with hemostasis and possible splenectomy. The maternal mortality is more than 75%, and the fetal mortality is more than 90% [329]. Therefore, splenic artery aneurysms should be surgically corrected even if asymptomatic [329,330]. Abdominal aortic and renal aneurysms can also rupture during pregnancy [331,332].

Bowel infarction can occur during pregnancy secondary to intestinal obstruction or mesenteric venous thrombosis [333,334]. Patients with mesenteric venous thrombosis typically have an insidious onset of poorly localized abdominal pain, with a relatively unremarkable physical examination [334,335]. The thrombosis is diagnosed by the noninvasive modalities of CT scanning or MR imaging and by the invasive modality of the venous phase of angiography [334]. Hematologic evaluation for hypercoagulopathy is recommended [333,334]. Laparotomy is required to remove necrotic or gangrenous bowel. Systemic anticoagulation is recommended.

Collagen vascular diseases and vasculitis syndromes usually have predominantly cutaneous, rheumatologic, or renal manifestations but occasionally produce gastrointestinal symptoms [336]. Systemic lupus erythematosus (SLE), may be exacerbated by pregnancy. Systemic lupus

erythematosus can cause abdominal pain from serositis or from mesenteric thrombosis resulting from the antiphospholipid (anticardiolipin) antibody syndrome associated with SLE [337]. Systemic lupus erythematosus is associated with pancreatitis. Thrombotic thrombocytopenic purpura and hemolytic uremic syndrome (HUS) are systemic disorders characterized by thrombocytopenia, microangiopathy, and ischemic manifestations including abdominal pain [204]. The maternal and fetal prognosis of TTP and HUS have dramatically improved with plasma exchange therapy [204]. Polyarteritis nodosa (PAN) can mimic preeclampsia and eclampsia by presenting with abdominal pain, pyrexia, malaise, hypertension, and renal dysfunction [338–340]. The maternal prognosis is good if the disease is in remission but is poor if the disease is active during pregnancy [338–340]. The fetus is not directly affected by PAN, and fetal survival is related to fetal age at delivery [339,340].

The sickle hemoglobinopathies are the most common hematologic disorders during pregnancy. They are prevalent in African Americans. Patients with hemoglobin SS, hemoglobin SC, and hemoglobin S/*B*-thalassemia have increased maternal mortality and morbidity, as well as fetal mortality [341–343]. Maternal mortality, however, has dramatically declined to less than 1%, and fetal mortality has dropped to less than 10% [342,343]. The infant often has a low birth weight and is born prematurely [342,343]. Patients with these hemoglobinopathies are prone to pulmonary embolus, pneumonia, other infections, preeclampsia or eclampsia, and sickle crises during pregnancy [343,344]. They can develop ischemia and microinfarction of multiple organs including extremities, joints, and abdominal viscera [344]. The abdominal pain in sickle crisis can be excruciating. Treatment includes intravenous hydration, analgesia, and possibly blood transfusions. Hemoglobin SS patients have an increased risk of acute cholecystitis during pregnancy [219,222,344].

Endocrinologic diseases

Glucose intolerance may initially present during pregnancy and even be limited to pregnancy, as in gestational diabetes. Tight glucose control during pregnancy improves pregnancy outcome and fetal birth weight [345]. Poorly controlled juvenile-onset diabetes may promote diabetic ketoacidosis, associated with abdominal pain [346]. Diabetic ketoacidosis can also cause acute pancreatitis from hypertriglyceridemia [347]. Diabetic neuropathy may cause abdominal or truncal pain [348]. Diabetes can also cause nausea, emesis, constipation, or diarrhea from gastroparesis diabeticorum or intestinal dysmotility.

Abdominal pain in hyperparathyroidism may be related to obstipation or nephrolithiasis from hypercalcemia. Addison's disease (glucocorticoid deficiency) is associated with nausea, emesis, and abdominal pain. Autoimmune thyroid disease is common in fertile women. Hyperthyroidism can

cause diarrhea (hyperdefecation) and crampy abdominal pain. Pheochromocytoma may manifest with abdominal pain during pregnancy [349].

Infectious diseases

Various acute and chronic infections can occur during pregnancy. Viral or bacterial gastroenteritis is a common and usually self-limited malady that is incidental to pregnancy. Symptoms include diarrhea, nausea, emesis, and abdominal pain. Bacterial colitis is usually diagnosed by stool analysis. Human immunodeficiency virus infection is a global pandemic. Infected women, sometimes unaware of their status, may become pregnant. Such patients are prone to opportunistic bacterial, fungal, parasitic, and viral infections, including enteric infections. This subject is considered in detail in another article in this issue. Unusual infections should also be considered in international travelers, immigrants, and health care workers. Malaria and abdominal tuberculosis can cause abdominal pain during pregnancy [350,351]. Malaria is still common in much of Africa. Tuberculosis is a global scourge. Abdominal tuberculosis may mimic Crohn's disease or cause ascites.

Drugs and toxins

Nonsteroidal anti-inflammatory drugs, including aspirin, can cause gastric or intestinal ulceration. These ulcers more commonly cause gastrointestinal bleeding than abdominal pain, possibly because of the analgesic properties of NSAIDs [154]. Intentional or accidental ingestion of acidic or alkaline corrosive agents can cause gastroesophageal injury [352]. Several drugs can cause pancreatitis or hepatitis [353,354]. Cocaine abuse is associated with uterine prolapse, preeclampsia, eclampsia, hepatic rupture, and mesenteric ischemia [271,355]. Digoxin, ergot alkaloids, and other vasoconstrictors are associated with mesenteric ischemia [356]. Black widow spider (*Latrodectus mactans*) bites in pregnancy can cause clinical findings similar to those of preeclampsia including abdominal pain, headache, hypertension, and proteinuria. The prognosis is good if antivenom and local measures, such as débridement, are promptly administered [357].

Extraabdominal causes of abdominal pain

As aforementioned, the perception of abdominal pain may result from extraperitoneal pathology in the brain, including abdominal migraine; in the thorax, including inferior wall myocardial infarction, right-sided congestive heart failure, pericarditis, endocarditis, pulmonary embolus, and pneumonia [358,359]; in the spine, including disc herniation, degenerative joint disease, discitis, neoplasms, and scoliosis [360,361]; in abdominal wall tissues, including umbilical herniation, and hematomas; and in nerves from

herpes zoster reactivation, diabetes mellitus, thyroid disease, and nerve entrapment [348,362–364]. Accelerated osteoporosis during pregnancy occasionally causes abdominal or pelvic pain [365]. Acute pelvic pain may present during pregnancy. It may resolve or persist postpartum [366].

Idiopathic abdominal pain during pregnancy

Pregnant women occasionally have idiopathic abdominal pain [215,367,368]. About 1% of laparoscopies performed for abdominal or pelvic pain in pregnancy reveal no cause of pain [368]. Many of these patients have psychologic stress that affects the irritable bowel syndrome [167,169,199]. Pregnant women with idiopathic abdominal pain are often single, are smokers, and have financial problems [367].

Munchausen's disease, a factitious disorder with physical manifestations including abdominal pain, can occur during pregnancy [369,370]. Patients require a comprehensive diagnostic evaluation to exclude organic disease and to avoid surgical intervention. This diagnosis should be considered in patients with multiple hospitalizations for the same complaint, especially when prior laparotomies have been nondiagnostic [369,370]. Psychiatric evaluation and therapy is required.

Summary

Numerous medical, surgical, psychiatric, gynecologic, and obstetric disorders can cause abdominal pain during pregnancy. The patient history, physical examination, laboratory data, and radiologic findings usually provide the diagnosis. The pregnant woman has physiologic alterations that affect the clinical presentation, including atypical normative laboratory values. Abdominal ultrasound is generally the recommended radiologic imaging modality; roentgenograms are generally contraindicated during pregnancy because of radiation teratogenicity. Concerns about the fetus limit the pharmacotherapy. Maternal and fetal survival have recently increased in many life-threatening conditions, such as ectopic pregnancy, appendicitis, and eclampsia, because of improved diagnostic technology, better maternal and fetal monitoring, improved laparoscopic technology, and earlier therapy.

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