Non-obstetric Intra-Abdominal Surgery During Pregnancy

35

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Bullet Points

- 1–2% of pregnant women undergo non-obstetric intra-abdominal surgery.
- Appendicitis is the most common non-obstetric surgery performed in pregnant women.
- Focus on fetal well-being may erroneously dominate care decisions for pregnant women with intra-abdominal pathology; delayed surgery is associated with worse maternal and neonatal outcomes.
- Diagnostic imaging may require special considerations; however, pregnant women who have an indication for x-ray studies should not be denied them.
- Most imaging techniques, including CT, use an ionizing radiation dose below 50 mGy and should be offered to pregnant women if required for diagnosis.
- The American College of Obstetrics and Gynecologists (ACOG) recommends that MRI be utilized despite pregnancy when appropriate in both elective and emergency situations.
- Invasive radiology may be performed during pregnancy, including ERCP; some modifications may be introduced to minimize procedure duration and radiation exposure.
- The anesthetic technique and the medications used for anesthesia should be selected as guided by patient condition and the type of surgery required.
- Intraoperative fetal monitoring should be reserved for cases where an obstetrician is available and prepared, and intervention for fetal indications is possible without endangering the mother during the surgical procedure.
- Laparoscopy is safe and feasible during any trimester of pregnancy.

35.1 Introduction

The estimated incidence of non-obstetric intra-abdominal surgery is approximately 1–2% among all pregnant women [1]. Incidental non-obstetric surgery has been described at every stage of pregnancy: 42%, 35%, and 23% during the first, second, and third trimesters, respectively [2, 3]. Although fetal/neonatal teratogenicity

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concerns may be relevant, including the hazard of possible preterm birth, surgery should never be delayed if indicated according to nonpregnant criteria. The general consensus is that a pregnant woman should not be denied any requisite surgery, regardless of gestational age. The timing and choice of surgery should be based on urgency and diagnosis (i.e., solely the maternal indications for surgery).

Despite its relative rarity and some overlapping reports, overall 12,452 non-obstetric surgeries during pregnancy were reported in the literature between 1996 and 2002 [2]. Appendicitis and biliary tract disorders constitute the most common non-obstetric intra-abdominal conditions requiring abdominal surgery during pregnancy (excluding adnexa/ovarian and trauma surgery which is discussed in Chap. 34) [2].

35.2 Pre-surgery Diagnostic Imaging

Management of acute abdominal pain in a pregnant woman is a difficult diagnostic and clinical task, requiring a systematic evaluation of the entire abdomen (Fig. 35.1). The anatomical and physiological alterations which take place during pregnancy include changes in vital signs, cranial displacement of the appendix, and altered laboratory values, e.g., physiologic leukocytosis. Imaging may be limited due to the enlarged uterus and the conception products. In parallel, concerns may arise regarding maternal and fetal radiation exposure dose and the safety of iodinated and gadolinium-based contrast agents. Practitioners may unjustifiably hesitate to utilize radiologic techniques in the pregnant woman even in emergency conditions; such hesitation could lead to delayed diagnosis of life-threatening conditions.

35.2.1 Ionizing Radiation Techniques

X-ray studies: Pregnant women who have an indication for x-ray studies should not be denied them due to pregnancy. Exposure to ionizing radiation doses of less than 50 mGy has not been associated with more adverse pregnancy outcomes than exposure to contemporary life background radiation alone. Most diagnostic imaging techniques use an ionizing radiation dose below 50 mGy and should be offered to pregnant women if appropriate to the diagnostic goal and the facilities available [4, 5].

The teratogenic and carcinogenic effects of ionizing radiation on the developing fetus have been ascertained and are addressed in guidelines released by the American College of Radiology (ACR) [6, 7]. Radiation teratogenicity is dose-dependent. In the preimplantation-organogenesis stages, an embryo radiation dose of 50–100 mGy may cause failure of implantation and spontaneous abortion. The developing fetus between 8 and 15 weeks of gestation is most sensitive to radiation; fetal radiation doses above 100–200 mGy are associated with intrauterine growth restriction, microcephaly, and neuro-developmental impairment. After the 15th gestational week, the fetus is less sensitive to radiation effects on the central nervous system. An increased risk of malformation has been reported at fetal doses above 150–200 mGy, and fetal damage has been reported to occur at exposures greater than 500 mGy [8]. The carcinogenic risk of ionizing radiation is still controversial at doses less than 100 mSv. The association of exposure to radiation on the risk of developing childhood cancers may be greater if exposure occurs earlier in the pregnancy [8].

Computerized tomography (CT): CT is an essential imaging modality in the acute setting where it can serve as a triage tool, thus preventing delays in diagnoses that might result in increased morbidity and mortality. The diagnostic use of CT has increased in the general population and is also acceptable for pregnant women [9, 10]. In any clinical setting, emergent or otherwise, this diagnostic modality should not be denied in pregnancy when indicated. However, radiation dose reduction techniques, for example, thicker slices, may be utilized [11].

Ultrasound is useful in diagnosing acute appendicitis in pregnant women and may prevent unnecessary surgery [12, 13]. However, despite encouraging reports in the literature [14, 15], the rate of visualization of the appendix on ultra-

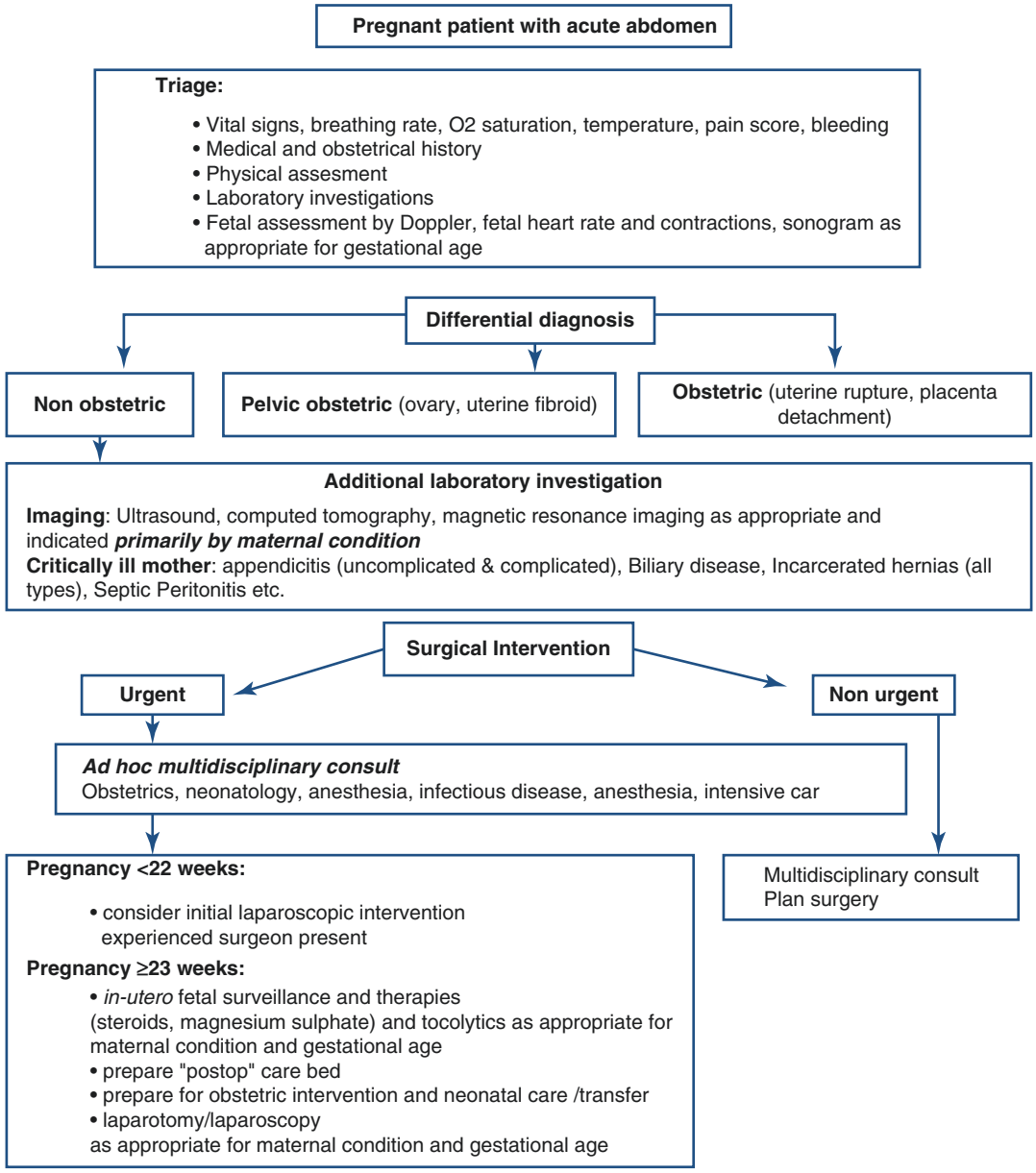

Fig. 35.1 Diagnostic algorithm for pregnant woman with acute abdomen

sound remains low among pregnant women at an advanced gestational age. The ability of ultrasound to diagnose other nonpregnancy-related abdominal pathologies such as colitis, distended stool-filled colon, diverticulitis, omental infarct, partial small bowel obstruction, and terminal ileitis is also relatively limited. Therefore the focus of imaging in pregnant women with abdominal pain has shifted to MRI.

Magnetic resonance imaging (MRI): Noncontrast MRI has become an integral part of the workup of abdominal pain in pregnancy and the initial triage assessment [16–19]. The American College of Obstetrics and Gynecologists (ACOG) recommends that MRI be utilized despite pregnancy when appropriate in either elective or emergency situations. More recent ACR guidelines state that MRI may be used in

pregnant women regardless of gestational age when the benefit outweighs the risks, as determined by an experienced MRI radiologist [20].

Although MRI has hitherto not been associated with known adverse fetal effects [7], the potential risk of heating effects from radiofrequency pulses, and the effects of acoustic noise on the human fetus have not been thoroughly or systematically evaluated [21–27]. The International Radiation Protection Association (ICNIRP) initially recommended postponing elective MRI until after the first trimester in pregnant women; however, this conservative recommendation was issued before the widespread application of this technique and its benefits to maternal soft tissue contrast and intracranial vascular diagnoses [28].

In order to determine the risk-benefit ratio of performing an MRI during pregnancy, the ACR recommends that three questions be answered:

1. Could the information be obtained by ultrasound?
2. Will this study likely impact or change the care of the patient?
3. Could this study be postponed until the patient is no longer pregnant?

Alternative options are more relevant in the earlier stages of pregnancy when the uterus and fetus do not obscure the abdominal viscera and vasculature. Furthermore, in most acute/emergency situations, the potential diagnostic benefit derived from use of MRI is believed to outweigh the risks even in the first trimester.

The optimal MRI protocol for investigating abdominal pain during pregnancy remains unclear. Until it is clarified, there are means of modifying the MRI protocol in order to decrease the likelihood of fetal risk without compromising the mother. For example, one study showed in a large cohort of pregnant patients that MRI has high diagnostic value in the workup of acute appendicitis: 100% negative predictive value and sensitivity and 99.5% specificity [29]. In pregnant patients with suspected appendicitis, the diagnostic performance of MRI remained unchanged if sagittal or both coronal and sagittal SSH-T2WI were omitted [30]. Furthermore, performance of MRI may prevent unnecessary surgery in pregnant women; one study showed that this imaging modality provided an alternative diagnosis for abdominal pain in nearly half of the exams deemed negative for appendicitis in this population, leading to reevaluation of therapeutic options [29].

Intravenous contrast media: Current knowledge regarding the effects of gadolinium and iodinated contrast agents on the human embryo or fetus is limited. Iodinated contrast material crosses the human placenta and is absorbed into the fetal thyroid. It may therefore cause neonatal hypothyroidism. However, this effect is unlikely with a single dose, thus it seems even less likely that a single dose would be teratogenic [31, 32]. The fetal half-life of gadolinium is unknown. Animal studies show that gadolinium crosses the placenta and appears in the fetal bladder. These models are currently used to extrapolate findings as to the effects of gadolinium in humans, which is at this point hypothetical. In these models, once gadolinium has passed the placenta it remains in the amniotic fluid; the fetus can excrete, swallow, and reabsorb gadolinium via the gastrointestinal tract for an indefinite amount of time [22, 23]. Limited evidence from animal studies suggests that gadolinium does have a teratogenic effect [33]. Thus, gadolinium should be used during pregnancy only if considered justified for maternal benefit by experts.

Some procedures such as endoscopic retrograde cholangiopancreatography (ERCP) have typically been avoided in pregnancy. However, when faced with an explicit indication such as cholangitis, biliary pancreatitis or symptomatic choledocholithiasis, ERCP is a less invasive approach than surgery for bile duct pathology [34]. Furthermore, postponement of ERCP carries significant maternal morbidity and increases the risk for preterm delivery as well as for adverse fetal and neonatal outcomes [34]. Strategies to perform ERCP in pregnancy with minimal fluoroscopy exposure include using modern equipment, minimizing the exposure time, minimizing exposure, maintaining the image intensifier close to the patient and the required image site, limiting use of the enhanced modes (boost and magnifica-

tion), and using a low frame rate [35]. Additional suggestions to limit exposure include use in the manual mode with higher kV (at least 75) and lower mA settings and keeping time for the endoscopist in order to increase awareness and potentially limit exposure time. Pregnancy appears to be an independent risk factor for post-ERCP pancreatitis, with an odds ratio 2.8, (95%CI 2.1–3.8) [36]. This may be related to the attempts to limit fluoroscopy during cannulation or to an inherent mechanism associated with pregnancy.

35.3 Maternal Considerations and Outcomes

A focus on fetal well-being may erroneously dominate care decisions for pregnant women with intra-abdominal pathology. This is a concern and may contribute to surgical care that differs in pregnancy when compared to the nonpregnant state.

35.3.1 Maternal Morbidity

A study of 9714 pregnant women with biliary disease demonstrated advantages to surgical management of pregnant women (i.e., with cholecystectomy); these women had significantly lower rates of maternal (4 vs 17%) and fetal (6 vs 17%) complications versus women managed conservatively. In the same study, after matching pregnant women to nonpregnant controls (according to age and primary diagnosis), a higher likelihood of open (rather than laparoscopic) cholecystectomy was reported, while there were more surgical complications among women undergoing an open procedure [37].

35.3.2 Maternal Mortality

Among 2000 pregnant women who underwent non-obstetric surgery as reported by Erekson et al., the mortality rate was 0.25% [38]. Four of the five women who died had intra-abdominal surgery; preoperative risk factors for death included emergency surgery, systemic inflammatory response syndrome and septic shock [38]. A literature search [39, 40] revealed only one report of maternal death following laparoscopic cholecystectomy in the 20th week of pregnancy. This mother died due to massive intra-abdominal hemorrhage 2 weeks postoperatively. However, maternal "near miss" events are underreported following surgery (see also Chap. 3). The diagnosis may be delayed and related to hemorrhage, obesity, other related thromboembolic phenomena, sepsis due to delayed diagnosis, and surgery for perforation of viscus [41].

35.4 Fetal and Neonatal Outcomes

Pregnant women who must undergo non-obstetrical surgery should be informed of the risks to their pregnancy, but at the same time it must be clarified that these considerations are always superseded by maternal well-being.

35.4.1 Miscarriage

Women may be concerned about the risk of miscarriage following intra-abdominal surgery. Overall, 6% of pregnant women who undergo any surgical intervention will report miscarriages [2]. Pregnant women exposed to a surgical intervention during the first trimester had a high (10.5%) reported rate of miscarriage [2]. It is difficult to assess the relative contributions of the surgical condition, the surgical technique, and individual maternal risk factors (e.g., age, previous reproductive techniques to achieve pregnancy, comorbidities); thus, these miscarriage reports should interpreted with caution when counseling pregnant women who require non-obstetric intra-abdominal surgery.

35.4.2 Preterm Delivery

Many studies have reported an increased incidence of premature delivery after non-obstetric surgery [42, 43] .This finding may be attributed

to the surgery itself, to manipulation of the uterus or to maternal underlying conditions (i.e., sterile inflammation, infectious inflammation, sepsis). The most recent estimate of the overall rate of prematurity related to non-obstetric surgery is approximately 8.2% [2], which is actually comparable/lower than the overall preterm birth rate in the developed world, which ranges between 5.5 and 11.5% [42, 43].

Unfortunately, there is little recent progress for prevention of preterm birth. Traditionally, open abdominal techniques and surgeries that do not manipulate the uterus have been associated with the lowest risk for preterm labor during the second trimester [44]. Given the newer evidence regarding the rates of preterm delivery and potential maternal complications stemming from modified surgical techniques, an informed discussion should be conducted with the mother regarding the preferred mode of surgery.

35.5 Anesthesia Considerations

Patient positioning and resuscitation: Increased intra-abdominal pressure can lead to decreased inferior vena caval return, resulting in decreased cardiac output and subsequent maternal hypotension or hypoxia. The fetus is dependent on maternal hemodynamic stability [45]. Therefore, to minimize surgical risk, gravid patients with hemodynamic compromise should optimally be positioned in a 15° left-tilted supine position. Minimizing the degree of reverse Trendelenburg position for upper abdominal surgery may also further reduce uterine compression of the vena cava. If a laparoscopic technique is used, gas insufflation should be limited as noted above. If required, maternal resuscitation should be conducted vigorously following standard protocols (for additional details see Chaps. 7, 27 and 28) as management principles are similar.

Choice of antibiotics: Surgical site infection is an ongoing concern in pregnant women undergoing non-obstetric surgery. As noted above, the laparoscopic approach has been associated with a lower rate of infectious complications than the open approach in both appendectomies and cholecystectomies in pregnant women [46]. Multiple studies have shown that delaying antibiotic administration until after cord clamping during obstetric surgery (namely, cesarean delivery) results in significantly increased rates of composite maternal postpartum infectious morbidity as compared with administration before surgery; this, without affecting neonatal outcomes [47]. As the fetus is intended to remain in situ, there is no point in delaying antibiotic treatment to any time other than that recommended by the guidelines for the general population. To date there is no support for a change in the routine antibiotic therapies, and pregnant women should receive those recommended for the non-obstetric population (see Chap. 38). Future studies should be directed toward protocols and safety of prophylactic antibiotics for non-obstetric surgery during pregnancy [39].

Anesthetic technique: The choice of anesthetic technique and the selection of appropriate anesthetic drugs should be guided by patient condition and the type of surgery required. Anesthetic considerations for the critically ill patient including aspiration risk and management of the obstetric airway are detailed elsewhere in this book (see Chap. 21).

Fetal preparation and monitoring: Once a decision has been made that a pregnant woman requires non-obstetric intra-abdominal surgery, several measures should be undertaken to optimize neonatal outcome. These include administration of steroids to promote fetal lung maturation until 34 weeks gestation, tocolytics, and neuroprotective magnesium sulfate administered intravenously as a 6 g bolus followed by a constant infusion of 1–2 g/h for up to 12 h between 24 and 31 + 6 weeks [48–50]. High-dose steroids may depress the normal physiologic immune response to sepsis. Tocolytics and magnesium may cause vasodilation, causing an additional, secondary decrease in blood pressure in an already septic patient. On the other hand, the effects of steroids on fetal lung maturation occur hours after administration. As the potential side effects of these drugs could endanger the mother if given unnecessarily, decisions regarding the timing of their administration should be preceded by multidisciplinary discussion of their potential risks versus their benefits. However, if any of the above inter-

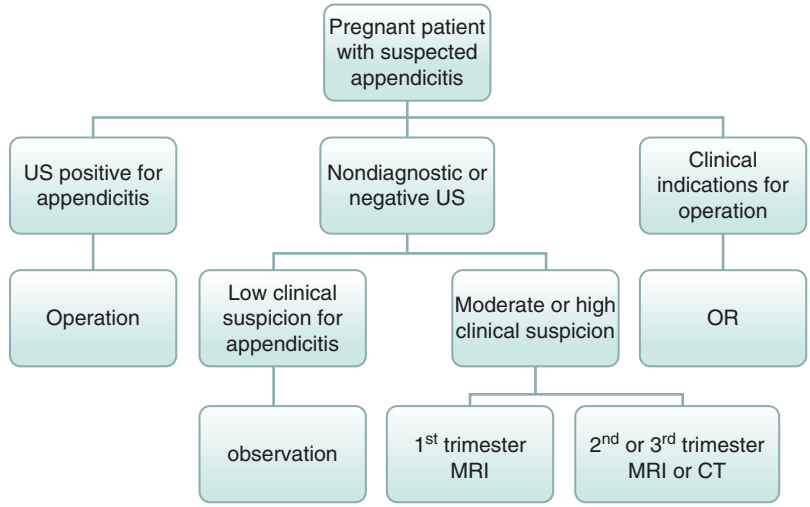

Fig. 35.2 Diagnostic algorithm for pregnant woman with suspected appendicitis. Reproduced with permission from Freeland M, King E, Safcsak K, Durham R. Diagnosis of appendicitis in pregnancy. The American Journal of Surgery, 2009; 198:753–758

ventions are not immediately available, surgery should not be delayed for their administration.

If the fetus is considered previable, the fetal heart rate should be ascertained by Doppler before and after the surgical procedure. In cases where the fetus is considered to be viable, electronic fetal heart rate and contraction monitoring should be performed before and after the surgical procedure. The decision whether to perform electronic fetal monitoring intraoperatively is not always easy. This decision should be guided by the surgical technique required and discussed in a multidisciplinary setting. Intraoperative monitoring should be reserved for cases where an obstetrician is available and prepared to intervene during the surgical procedure for fetal indications. Such intervention should never endanger the mother. The gestational age must be appropriate and neonatal care must be available. These considerations are outlined in the Committee Opinion on Non-obstetric Surgery During Pregnancy of the American Society of Anesthesiologists [51].

35.6 Specific Intra-abdominal Surgical Conditions

35.6.1 Appendicitis

Suspected appendicitis is the most common indication for non-obstetric surgery in pregnancy; it occurs in approximately 1:500–2000 pregnancies annually [52], accounting for one-quarter of all non-obstetric indications for surgery during pregnancy, Fig. 35.2. The first and second trimester are the most common periods for appendicitis; 7.4 and 7.3/10,000 person years, respectively, and it is less frequent during the third trimester (4.6/10,000 person years) [53]. The diagnosis of appendicitis is particularly difficult during pregnancy due to blunting of the signs of peritonitis and altered appendix location. Typically, appendicitis in pregnancy is associated with right lower quadrant pain and direct abdominal tenderness is frequently noted; however, rebound and guarding may be absent. As noted above, anatomical and physiological changes complicate diagnosis; the increase in uterine volume displaces the appendix, and the presence of physiological leukocytosis is also misleading. Pain may present in the back or flank, suggesting renal pathologies. Psoas irritation may be absent altogether [52].

As note above, clinicians may mistakenly be reluctant to use imaging techniques to advance the diagnosis. After diagnosis is made there may also be some hesitation to operate, particularly in women with advanced gestational age. Such hesitation may lead to unnecessary delays in diagnosis and treatment. The risk of appendix perforation is high, particularly when surgery is delayed for more than 24 h after onset of symptoms [54]. Reports describe perforation rates ranging between 14 and 43% among pregnant women undergoing appendectomy [55, 56]. A ruptured

appendix is subsequently 3–10 times more common in women, and specifically in pregnant women in the third trimester of pregnancy and the immediate postpartum period, versus the reported rate for the general adult population [57–63].

Recent suggestions of conservative antibiotic therapy for patients with uncomplicated appendicitis may appeal to those reluctant to perform surgery during pregnancy [64]. Furthermore, the diagnosis of "uncomplicated versus complicated" appendicitis in pregnancy may prove difficult to ascertain. However, non-operative management of appendicitis may lead to high maternal morbidity. One study compared patients with appendicitis managed using conservative versus surgical management; 6% of the study cohort was pregnant. Among these pregnant women, there were statistically significant higher rates of maternal morbidity with conservative management. These included a sixfold increase in the risk of septic shock (OR 6.3; 95% CI 1.9, 20.8), a one-and-a-half times higher likelihood of peritonitis (OR 1.6; 95%CI 1.3,2.1) and a greater than twofold increase in venous thromboembolism [65]. In a UK cohort of 362,219 pregnancies with appendicitis, the third trimester was reportedly a challenging period to diagnose appendicitis [53].

The complications related to appendicitis even with appendectomy are significantly higher in pregnant women as compared to nonpregnant women. One study showed that the rates of peritonitis were 20.3% in pregnant women with appendicitis versus 16.1% in nonpregnant women with appendicitis (OR 1.3; 95%CI 1.2, 1.4); sepsis and septic shock were also more common in the pregnant population. The rates of transfusion, bowel obstruction, pneumonia, and other postoperative infections, as well a hospital stay of more than 3 days, were also increased [65]. Additionally, an open surgical approach is more often chosen when surgery is performed during pregnancy, especially when the enlarged uterus poses a challenge to the laparoscopic approach. The increased maternal morbidity associated with appendicitis in pregnancy may therefore be explained not only by the increased rate of peritonitis but also by a twofold increase in laparotomy as compared to the general population; laparoscopy is used in only 43–58% of women with appendicitis [65, 66]. For women who remain pregnant, the risk of dehiscence of the appendectomy incision during labor and vaginal delivery is unlikely to be increased when the aponeurosis is properly approximated [67]. A study using a US database found that among 7114 pregnancies complicated by appendicitis, preterm birth and cesarean delivery were significantly more likely in women with peritonitis, reflecting a delayed diagnosis or more severe disease [68]. Maternal mortality is estimated to be low when appendicitis is promptly diagnosed and treated [69, 70].

35.6.2 Recommended Surgical Approach to Appendectomy

Regardless of the surgical procedure at hand, the choice to apply laparoscopy during pregnancy is best determined by the anatomical point of access, the length of the procedure and subsequent duration of exposure to anesthetics, the difficulty of patient positioning for optimal respiratory support, maternal and fetal oxygenation demands, and ultimately, the training and experience of the surgeon (Fig. 35.3). The complexity of surgical intervention increases with gestational age. Laparoscopy during pregnancy is best performed by an experienced surgeon in a tertiary medical center, with facilities to manage delivery and the neonate if the pregnancy is viable [51]. If no such option exists and the mother has been admitted to a medical center with limited laparoscopic surgery experience, open surgery may be the better option [71, 72].

The optimal surgical approach to a pregnant woman with suspected appendicitis is through a transverse incision in McBurney's point. Equally good alternatives surgical approaches to the diagnosis and treatment of surgical conditions that may mimic appendicitis include incision at the point of maximum sensitivity or a midline vertical incision from the umbilicus to the ramus pubis. Uterine traction and handling of the uterus should be minimal.

Both early and later reports agree that laparoscopic appendectomy can be performed during all trimesters with few maternal complications

Ultrasongraphic imaging during pregnancy is safe and useful in identifying the cause of acute abdominal pain in the pregnant patient (moderate; strong).
Expeditious and accurate diagnosis should take precedence over concerns for ionizing radiation. Cumulative radiation dosage should be limited to 5–10 rads during pregnancy (moderate; strong).
Contemporary multidetector computed tomography protocols deliver a low radiation dose to the fetus and may be used judiciously during pregnancy (moderate; weak).
MRI without intravenous gadolinium can be performed at any stage of pregnancy (low; strong).
Adminidtration of radionucleotides for diagnostic studies is generally safe for mother and fetus (low; weak).
Intraoperative and endoscopic cholangiography exposes the mother and fetus to minimal radiation and may be used selectively during pregnancy. The lower abdomen should be shielded when performing cholongiography during pregnancy to decrease the radiation exposure to the fetus (low; weak).
Diagnostic laparoscopy is well tolerated and effective when used selectively in the workup and treatment of acute abdominal processes in pregnancy (moderate; strong).
Laparoscopic treatment of acute abdominal disease has the same indications in pregnant and nonpregnant patients (moderate; strong).
Laparoscopy can be safely performed during any trimester of pregnancy (moderate; strong).
Gravid patients should be placed in the left lateral decubitus position to minimize compression of the vena cava (moderate; strong).
Initial abdominal access can be safely performed with an open (Hasson) technique, Veress needle, or optical trocar, if the location is adjusted according to fundal height and previous incisions (moderate; weak).
CO_2 insufflation of 10–15 mmHg can be safely used for laparoscopy in the pregnant patient (moderate; strong).
Intraoperative CO_2 monitoring by capnography should be used during laparoscopy in the pregnant patient (moderate; strong).
Intraoperative and postoperative pneumatic compression devices and early postoperative ambulation are recommended prophylaxis for deep venous thrombosis in the gravid patient (moderate; strong).
Laparoscopic cholecystectomy is the tratment of choice in the pregnant patient with gallbladder disease, regardless of trimester (moderate; strong).
Choledochlithiasis during pregnancy may be managed with preoperative endoscopic retrograde cholangiopancreatography with sphincterptomy followed by laparoscopic cholecystectomy, laparodcopic comman bile duct exploration, or postoperative endoscopic retrograde cholangiopancreatography (moderate; strong).
Laparoscopic appendectomy may be performed safely in pregnant patients with appendicitis (moderate; strong).
Laparoscopic adrenalectomy, nephrectomy, splenectomy, and mesenteric cyst excision are well tolerated procedures in pregnant patients (low; weak).
Laparoscopy is a well tolerated and effective treatment in gravid patients with symptomatic ovarian cystic masses. Observation is acceptable for all other cystic provided ultrasound is not concerning for malignancy and tumor markers are normal. Initial obeservation is warranted for most cystic lesions <6 cm in size (low; strong).
Laparoscopy is recommended for both diagnosis and treatment of adnexal torsion unless clinical severity warrants laparotomy (low; strong).
Fetal heart monitoring should occur pre and postoperatively in the setting of urgent abdominal surgery during pregnancy (moderate; strong).
Obstetric consultation can be obtained pre and/or postoperatively based on the severity of the patient's disease and availability (moderate; strong).
Tocolytics should not be used prophyloctically in pregnant women undergoing surgery but should be considered perioperatively when signs of preterm labor are present (high; strong).

Fig. 35.3 Guidelines for laparoscopic surgery suring pregnancy, developed under the auspices of the Society of American Gastrointestinal Endoscopic Surgeons (taken from non-obstetric anesthesia during pregnancy, Heesen et al. Curr Opin Anesthesiol 2016, 29:297–303)

[73–77] even after perforation [46]. A systematic review [78] of laparoscopic management for non-specific abdominal pain and suspected appendicitis among pregnant women concluded that laparoscopy was beneficial, with a high rate of specific diagnoses and a low rate of removal of normal appendices compared with open appendectomy. To minimize risk, use of any instruments in the cervix should be avoided altogether. Trocar insertion should only be performed under direct vision, and the location of insertion should take into account uterine size. Gas insufflation should be minimized and insufflation pressures should not exceed 10–15 mmHg.

While there are some reports of an increased rate of fetal loss when compared with open appendectomy (OR 1.91, 95% CI 1.31–2.77%) [79, 80], none of those studies are adjusted for confounders (e.g., maternal age, gestational age, complicated appendicitis, surgeon experience).

35.7 Biliary Tract Disease

Approximately 0.05–0.8% of pregnant women have symptomatic gallstones [81]. Among 1,064,089 pregnancies, 1882 (0.2%) had gallstone disease. Of these, 239 (13%) had an antepartum

cholecystectomy and 1643 (87%) were managed conservatively. Of those managed conservatively, 319 (19%) had a postpartum cholecystectomy [82]. Biliary surgery and biliary procedure type should not be delayed and indications should be as for nonpregnant patients. Delays are associated with worse outcomes [39]. Surgery may be required for perforated gallbladder, common bile duct obstruction or for repeated attacks of biliary colic and biliary pancreatitis, as for any patient. Current evidence supports selecting a treatment approach similar to one acceptable for the general population.

In the general population, a conservative approach with administration of antibiotic therapy alone has been associated with poorer outcomes than in an open surgical approach, and both are associated with poorer outcomes than closed drainage [83]. Nonsurgical (conservative) management, including antibiotics and intravenous fluid supplementation, has also been reported in pregnant women. In this population too this approach has been associated with high rates of symptom recurrence and disease progression [52, 84, 85]. Furthermore, pregnant women with biliary tract disease who were managed conservatively had a higher risk of maternal readmission (ARR [absolute risk reduction] 4.7, 99% CI 4.2, 5.3) and one in five (19%) eventually underwent postpartum cholecystectomy [82]. Although most women with gallstones are managed conservatively during pregnancy, surgical management decreases the readmission rates [82]. Despite this, most women with biliary tract disease during pregnancy remain managed conservatively [86].

No differences have been observed in mode of delivery or preterm birth rates for women treated surgically versus conservatively. However, pregnant women with symptomatic gallstones causing biliary pain or with biliary complications such as acute cholecystitis or pancreatitis have a higher risk of planned preterm birth as compared to women with an incidental finding of gallstones (ARR (absolute risk reduction) 1.6, 99%CI 1.2, 2.1). This likely reflects caregiver anxiety rather than the natural course of the disease or therapy [86].

Despite the fact that symptomatic biliary tract disease is a leading indication for emergency non-obstetric surgery, fetal death has not been reported in association with this type of surgery. This may be based on the natural course of the disease, which rarely causes viscus perforation, or on timely and accurate diagnosis of biliary complications when compared to the diagnosis of appendicitis [81, 87, 88]. However, one cohort study did report an increased risk of preterm birth, jaundice, small-for-gestational age, respiratory distress syndrome, and intrauterine fetal death associated with pancreatitis secondary to gallstone disease during pregnancy, regardless of surgical management [82]. While these are rare complications, the mother should be informed of these risks, and they should not be disregarded.

35.7.1 Recommended Surgical Approach to Cholecystectomy

The operative management of symptomatic cholelithiasis (biliary colic, acute and chronic cholecystitis, choledocholithiasis, and biliary pancreatitis) during pregnancy can be either laparoscopic or open cholecystectomy. Traditionally, the timing of laparoscopic or open biliary tract surgery in pregnancy was determined mainly by gestational age; if the disease presented during early pregnancy, the thought was that nonemergency surgery could be delayed until the second trimester (Fig. 35.3). By this time, the risk of miscarriage was believed to be lower, the risk incurred by exposure to anesthetics decreased, and there was still the benefit of operating in an abdomen without an overly large gravid uterus [87]. A recent meta-analysis compared the surgical laparoscopic approach to the open approach and reported that laparoscopic surgery is associated with significantly fewer maternal and fetal complications, less surgical complications, and a shorter hospital stay despite similar duration of surgery [40]. However, 91% of the women in this meta-analysis were in the first or second trimester at the time of surgery [40], and most cholecystectomies (63.4%) were performed during the

Table 35.1 Differential diagnosis for right upper quadrant pain in pregnancy

Appendicitis
Cholangitis
Cholecystitis
Cholelithiasis
Hepatitis
Liver hematoma
Pancreatitis
Peptic ulcer
Pneumonia
Pyelonephritis

second trimester. As pregnancies advanced into the third trimester, there was an increasingly greater likelihood of open surgery [40]. Although the reasons for performing open surgery in advanced pregnancies were not stated in any of the studies, they are presumably related to technical considerations. These may include limited operative space, difficulties in managing the required surgery with the required alteration in laparoscopic port placement and poorer visualization of the operative field due to obstruction by the gravid uterus. Regardless of cause, this finding supports early intervention for symptomatic gallstones (i.e., in the first and second trimester), as at this time a laparoscopic approach is more likely to be used. The one caveat to this recommendation is the fact that the only maternal death report was in the laparoscopic group (0.001%). The rate of preterm delivery seemed slightly higher after laparoscopic surgery, but this finding did not reach statistical significance. Whether this finding stemmed from the limited sample size or from actual lack of increased risk remains unclear [40] (Table 35.1).

35.8 Hernias

Another cause of emergency non-obstetric surgery during pregnancy is hernias that may become incarcerated or strangulated due to increased intra-abdominal pressure [89, 90]. Superficial surgical site infection was the most common morbidity in pregnant women undergoing open umbilical hernia repair [91]. The long-term recurrence rate of urgent complicated umbilical hernia repair performed in pregnant women has not been evaluated to date.

35.9 Obesity and Bariatric Surgery

Obesity and bariatric surgery have become increasingly common and thus merit special attention during pregnancy [91, 92]. During the first pregnancy after bariatric surgery, the rate of surgery for intestinal obstruction was 1.5% among women that had undergone bariatric surgery versus 0.02% among women with similar Body Mass Index and no previous surgery. The rate of diagnostic laparoscopy or laparotomy was also significantly higher (1.5 versus 0.1%) [93]. Young women who are considering bariatric surgery should be informed that this could potentially be an issue during pregnancy.

35.10 Robotic Surgery

At the time of this writing, the use of robotics for acute abdominal surgery has not been reported for pregnant women. There is a single report on the use of robotic surgery in ovarian cystectomy during pregnancy. Lower levels of intra-abdominal pressure were required for performing the six successful procedures described [94]. The authors postulated that the use of robotics increases dexterity, similar to an open procedure. They also postulated that performing laparoscopy in these women would likely have been accompanied by increased blood loss and even conversion to laparotomy.

35.11 Conclusions

Diagnosing the non-obstetric causes of acute abdominal/pelvic symptoms during pregnancy is challenging. Imaging should be used as required to optimize decision-making and to reduce the incidence of unfavorable maternal and fetal

outcomes. The most significant maternal risks are engendered by delays in treatment. The course of the intra-abdominal disease and overall maternal well-being will also determine fetal outcome. Fetal death is highest in perforated appendicitis (resulting from delayed care).

Non-obstetric surgery during pregnancy requires a multidisciplinary approach, including availability of neonatologists and specialized neonatal care. Anesthesia during intra-abdominal surgery in pregnant women is a challenge regardless of gestational age, as the intra-abdominal pathology compounds the risks of airway and circulatory compromise. Laparoscopy is safe and feasible in any trimester of pregnancy and may improve maternal outcomes without adversely affecting pregnancy outcomes.

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