29 Common Surgical Conditions Encountered During Pregnancy

Vivek Agrawal and Chiranjeet Singh Khurana

29.1 Acute Appendicitis

29.1.1 Relevant Anatomy

Appendix which is a true diverticulum arises most commonly from the posteromedial border of the cecum. The base of the appendix can be reliably located at the point where all three taeniae converge on the surface of cecum. The length of the appendix ranges from 5 to 35 cm with the average length being 9 cm [1]. The function of the appendix has traditionally been a topic of debate with none agreeing on one purpose.

The location of the appendicular orifice is consistent, i.e. at the base of the cecum but the position of its tip is not. The most common position of tip of appendix is retrocecal. The various positions of tip of appendix include retrocecal (reaching far into the hepatorenal recess in some cases), subcecal, pre-ileal and post-ileal, and pelvic (Fig. 29.1). The location of appendix also depends on factors such as posture, respiration, and distention of adjacent bowel which leads to variable clinical presentations of its diseases, especially causing inaccuracies in diagnosing appendicitis. Agenesis of the appendix as well as its duplication or triplication has rarely been described in the literature [2, 3]. With advancing pregnancy, the cecum is pushed cephalad by the enlarging uterus, displacing the appendix along with it; so much so that, by the end of the third trimester the pain of appendicitis may be perceived in the right upper quadrant of abdomen. This entails difficulty in differentiating it from the diseases of other organs placed in this region.

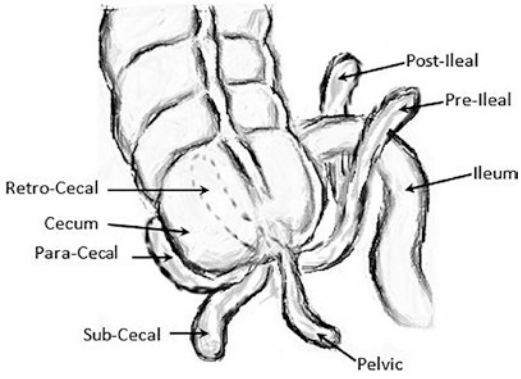

Fig. 29.1 Different positions of appendix. (Courtesy Sahil Juneja)

Appendicular artery, the terminal branch of the ileocecal artery, supplies the appendix. Ileocecal artery arises from superior mesenteric artery that nourishes the midgut. Lymphatic drainage from both the appendix and cecum reaches the ileocolic group of lymph nodes. The lymphatic fluid from the cecum drains via several

V. Agrawal (✉) · C. S. Khurana
Department of Surgery, University College of Medical Sciences & Guru Teg Bahadur Hospital, New Delhi, India

S. Mehta, A. Grover (eds.), *Infections and Pregnancy*, https://doi.org/10.1007/978-981-16-7865-3_29

intermediate mesenteric lymph nodes whereas the appendix drains via a single intermediate node. From the ileocolic lymph nodes, the lymph is directed to the superior mesenteric lymph nodes [4].

The sympathetic (autonomic) innervation of appendix arises from the superior mesenteric plexus. Afferent sensory fibers from the appendix are carried along the sympathetic plexus to enter the spinal cord at T10, which corresponds to the umbilical dermatome—thereby explaining the reason for periumbilical initiation of pain in acute appendicitis.

29.1.2 Introduction

Appendicitis is the most common nonobstetric general surgical emergency ailment encountered during pregnancy. Various challenges can be faced in its diagnosis due to non-classical presentation, displaced location of appendix by gravid uterus, occurrence of physiological leukocytosis of pregnancy and surgeon's bent to not to perform surgery upon a pregnant lady. These lead to increased risk of development of complications which can adversely affect the fetal outcome. Acute appendicitis is an important differential diagnosis in any pregnant lady presenting with sudden abdominal discomfort and the prompt management of the condition can definitely reduce the morbidity in both, the mother and the baby.

29.1.3 Incidence

The incidence of appendicitis during pregnancy varies between 1 in 800 and 1 in 1500 pregnancies [5]. The condition is more commonly seen during the second trimester but complications like perforation are more commonly seen during the third trimester, mostly due to delayed diagnosis.

Appendicectomy causes higher morbidity and mortality to the fetus than the mother. Fetal loss occurs in about 2% of uncomplicated appendectomies but the rate goes up to 36% in case it perforates [6]. On the other hand, there is no significant difference in morbidity and mortality following appendicectomy in pregnant and non-pregnant women. However, there is increased incidence of onset of preterm labor (10.6 vs. 5.9% in comparison group) [7].

29.1.4 Etio-Pathophysiology

It is same as in non-pregnant female. Most commonly appendicitis results from obstruction of appendicular lumen due to fecoliths, fruit and vegetable material, parasites, etc. followed by distension due to increased mucus secretion and gas production by bacterial fermentation. This leads to increase in luminal pressure that causes venous stasis followed by arterial insufficiency precipitating mucosal ischemia which progresses to involve the entire thickness of appendix wall and ultimately leading to gangrene and perforation of the affected appendix wall.

Distention of the appendix is responsible for the initial visceral and vague periumbilical abdominal pain stated by the affected patient. The pain does not typically localize over the right lower abdomen area, where the appendix is normally located, until the appendicular tip becomes inflamed—which then irritates the adjacent parietal peritoneum or perforates itself leading to localized peritonitis.

29.1.5 Clinical Presentation

Appendicitis can have both classical and non-classical presentation during pregnancy. Non-classical presentation becomes more common as the pregnancy advances. Classical presentation includes occurrence of periumbilical pain which is followed by nausea, vomiting, and occasionally fever. Non-classical presentation includes diarrhea, constipation, flatulence, heartburn, dysuria, etc.

The pain of appendicitis starts in the periumbilical region which then shifts to McBurney's point [junction of lateral 1/3rd and medial 2/3rd of an imaginary line joining umbilicus and anterior superior iliac spine (ASIS)]. This is evident

in early stages of pregnancy but later on, as the gravid uterus pushes the appendix cephalad, pain occurs in right flank and upper abdomen. Apart from this, the gravid uterus also distances the contact between anterior abdominal wall's parietal peritoneum and inflamed appendix; hence, often there is lack of tenderness and rebound tenderness in pregnancy, masking the true clinical picture of appendicitis leading to difficulty in diagnosis. Several other signs, Rovsing sign (presence of right lower quadrant pain on palpation of the left lower quadrant), the Obturator sign (right lower quadrant pain on internal rotation of the ipsilateral hip), and the Psoas sign (pain with extension of the ipsilateral hip) may be present during early pregnancy and depending on the location of appendix.

Various scores are used to improve accuracy of the diagnosis of appendicitis. These include Alvarado (Table 29.1), Eskelinen, Ohmann, AIR, RIPASA (Table 29.2), Tzanakis, Lintula, Fenyo-Lindberg, and Karaman systems. Although the most commonly used score among all is Alvarado score, its use in pregnancy has not demonstrated high accuracy as it has shown in non-pregnant women; but when Alvarado score is combined with CRP and RIPASA scores, it has yielded higher specificity to diagnose appendicitis in pregnant females, as confirmed in various studies [8].

Table 29.1 Alvarado score

	Features	Score
Symptoms	Migratory Pain	1
	Anorexia	1
	Nausea	1
Signs	Tenderness in right lower abdomen	2
	Rebound Tenderness	1
	Elevated Temperature	1
Laboratory Findings	Leukocytosis	2
	Shift of white blood cell count to left	1
	Total	10

Score 1–4: Acute appendicitis, very unlikely, keep under observation
Score 5–6: Acute appendicitis, may be, for regular observation
Score 7–8: Acute appendicitis, probable, operate
Score 9–10: Acute appendicitis, definite, operate

Table 29.2 RIPASA score

	Parameters	Score
Patients	Female	0.5
	Male	1
	Age <39.9 years	1
	Age >40 years	0.5
Symptoms	RIF Pain	0.5
	Pain Migration to RIF	0.5
	Anorexia	1
	Nausea & Vomiting	1
	Duration of Symptoms <48 h	1
	Duration of Symptoms >48 h	0.5
Signs	RIF Tenderness	1
	Guarding	2
	Rebound Tenderness	1
	Rovsing Sign	2
	Fever >37 °C < 39 °C	1
Investigation	Raised WBC	1
	Negative Urine Analysis	1
Additional Score	Non –Asian	1
Total score		17.5

Score < 5: Probability of acute appendicitis is unlikely
Score 5–7: Low probability of acute appendicitis
Score 7.5–11.5: Probability of acute appendicitis is high
Score > \ = 12: Definite acute appendicitis

29.1.6 Diagnosis

Accurate diagnosis is the most important step in managing appendicitis because negative appendectomy can be associated with a high risk of fetal loss and premature birth [5].

Leukocytosis: Physiological leukocytosis of pregnancy with neutrophils predominance, where counts as high as 16,000 cells/mm^3 seen during pregnancy may mask the leukocytosis due to the disease.

Ultrasonography: Its easy availability, low cost, and lack of ionizing radiation make it a good initial radiological investigation to diagnose appendicitis. However, presence of gravid uterus and displacement of appendix from its normal right lower abdomen location may lead to its non-visualization in 88–97% of the cases; USG has overall sensitivity between 20–40% and specificity 95–100% [9]. Thus, relying on USG may result in delaying diagnosis which increases the risk of complications.

Computed Tomography: The teratogenic effect of this diagnostic modality has to be weighed against its diagnostic accuracy. This risk is reduced during the later stages of pregnancy because organogenesis is already complete by that time. Incase we need to use CT scan in inconclusive cases, we should image a limited area to decrease radiation exposure; according to ALARA (as low as reasonably achievable) principle and also contrast should not be used. It has been found that radiation exposure less than 500 mGy has no teratogenic effect but there is 0.1% increased risk of childhood cancer following exposure to 100 mGy radiation [10].

Magnetic Resonance Imaging: It is a safer option as compared to CT scan as it has less teratogenic potential. It is more accurate than ultrasonography to visualize the appendix (50–60%) [10]. There is better characterization of pathologic tissue by MRI and it has the capability of direct multiplanar cross-sectional imaging. The reported sensitivity in pregnancy is 80–100% and specificity is 93–100% for diagnosing appendicitis. Various studies have shown MRI reduces the rate of negative appendectomies by 50% [10]. Its inconsistent availability in peripheral centers limits its use. Where MRI is not readily available and the potential risks of radiation to the fetal growth and development are outweighed by serious immediate complications that could result from a missed diagnosis, a CT scan should be considered to increase the pre-operative accuracy of the diagnosis.

29.1.7 Complications

If untreated, acute appendicitis can progress to severe complications with high morbidity. Appendicular perforation is one of the dreaded complications which can either lead to free peritonitis or contained/localized "walled-off" peritonitis.

Perforations cause dissemination of pus and fecal matter into the peritoneal cavity, which subsequently leads to sepsis and increases risk of preterm labor or fetal loss. Contained or walled-off perforations can cause intraperitoneal abscess or phlegmon; that forms around a burst appendix and requires extended antibiotic treatment and often a surgical drainage.

Complications of the surgery itself can be extensive and include infections (postoperative peritonitis, intraperitoneal abscess, surgical site infections, UTIs, pneumonia, etc.), bleeding, and damage to adjacent structures.

29.1.8 Treatment

Appendectomy remains the treatment of choice for all cases diagnosed as appendicitis in pregnancy.

Anesthesia: Appendectomy requires anesthesia and general anesthesia carries 17 times higher risk in pregnancy as compared to non-pregnant women [11]. Obese pregnant women have neck shortening which in association with edema and breast engorgement can result in difficult intubation. There is higher risk of aspiration of gastric contents (Mendelson's syndrome) and hypoxia. Also, pregnant women desaturate much quicker than non-pregnant counterpart (3 min as opposed to 9 min), especially if body mass index is high. All anesthetic induction and maintenance agents cross the placenta but effects are transient and if the neonate is born during general anesthesia, then ventilatory support is required to sustain the neonate until the effects of drugs wear off. So, regional anesthesia is preferred over general anesthesia, only risk being hypotension secondary to sympathetic blockade. Opiate analgesia is sufficient to control perioperative pain and use of NSAIDS should be avoided as they cause premature closure of ductus arteriosus, especially after 32 weeks.

Surgical Management: For appendicectomy, two main approaches are available—open and laparoscopic. Either may be adopted based on patient's preference, gestational age, and expertise of the surgeon. However, the Society of American Gastrointestinal and Endoscopic Surgeons (SAGES) guidelines advocate the use of laparoscopic appendectomy as the standard of care in pregnant patients owing to higher safety profile [12].

Some modifications are recommended while performing laparoscopic surgery in a pregnant lady which includes slight left lateral positioning of the patient (especially during the second half of pregnancy) to prevent aortocaval compression, the use of an open port access (Hasson technique) for initial trocar placement to avoid injury to the gravid uterus, limiting intra-abdominal insufflation pressure to less than 12 mmHg, and adjustment of port position commensurate to uterine fundal height [13].. While performing open surgery, mark the point of maximal tenderness and give incision on it and not necessarily at the McBurney's point. If a surgeon is not sure of the diagnosis, a lower midline vertical incision may be preferred as it helps to explore other organs whose affection can result in appendicitis like picture. All cases should be given broad spectrum good antibiotic coverage for gram-positive and gram-negative bacteria as well as anaerobes.

Management of complications: If the surgery is not performed within 24 h, there is increased risk of perforation. Perforation can be either free or contained. Free perforation is the one where there is spillage of contents into the peritoneal cavity causing generalized peritonitis resulting in a sick looking patient and adding to the risk of fetal loss. It is managed with urgent exploratory laparotomy, appendectomy, and drainage of peritoneal cavity. In case the perforation is walled off, resulting in abscess formation, then management is conservative with IV antibiotics, bowel rest, and IV fluids with close monitoring and minimal access or open surgical drainage. However, there is lack of sufficient data on conservative management of walled-off perforation in pregnant females. Pregnancy being a hypercoagulable state, a decision should be made to give thromboprophylaxis with low molecular weight heparin.

Fetal Monitoring: After the period of viability of fetus, i.e. 24 weeks is attained, fetal monitoring should be done both pre-operatively and post-operatively. If the fetal heart is not reassuring, continuous fetal monitoring may be required [14]. Inhalational agents which contain cardiodepressants and decreased sympathetic tone seen during pregnancy can cause maternal vasodilation leading to lowering of blood pressure with a resultant drop in uterine perfusion. Cardiotocography (CTG) changes consistent with fetal compromise can usually be reversed by maximizing maternal oxygenation, correcting hypovolemia and hypotension, and ensuring a left lateral tilt.

Obstetric Management: If the patient is critically ill and surgery is needed urgently, it should be done regardless of gestation, as maternal welfare is always a priority over and above the fetus. Appendicitis may cause irritation to the uterus and potentiates the risk of preterm labor. If the gestation is above 34 weeks, labor should be allowed to proceed. Antenatal steroids should be given between 24 and 34 weeks. Steroids should not be used in severe maternal sepsis as it may interfere with maternal immune responses. There is no risk of rupture of appendectomy scar during labor. C-section is for obstetric indications only and performed along with appendectomy if the gestation is 37 weeks or more. Fetal heart rate abnormalities are common and adequate analgesia should control it in most of the cases. Persistent abnormalities on CTG during planned appendectomy may warrant the need of C-section. Thus, simultaneous delivery is attempted only in case of severe fetal or maternal compromise and preferably as close to term as possible.

29.1.9 Differential Diagnosis

Other conditions, both surgical and gyneco-obstetric, should be considered in differential diagnosis. Common surgical conditions that may mimic appendicitis are cecal diverticulitis, Meckel diverticulitis, acute ileitis, inflammatory bowel disease (Crohn and ulcerative colitis), renal colic, and urinary tract infections. Gynecological conditions like tubo-ovarian abscess, pelvic inflammatory disease, ruptured ovarian cyst, ovarian, round ligament syndrome, and fallopian tube torsion are the differential diagnosis which should always be kept in mind. Obstetric conditions with similar presentation include placental abruption, uterine rupture, pre-eclampsia, HELLP (hemolysis, elevated liver

function tests, low platelets) syndrome. During early pregnancy, ectopic pregnancy is a very important differential diagnosis which needs to be excluded.

29.1.10 Prognosis

Appendectomy in pregnancy has similar morbidity and mortality as that in non-pregnant females. The greater risk is for the fetus inside the womb.

Risk of fetal loss in appendicitis and related conditions is as follows [6, 7]:

- In uncomplicated appendectomy—2%
- In case of generalized peritonitis and abscess—6%
- In negative appendectomy—4%

Risk of preterm labor due to appendectomy is as follows [6, 7]:

- In uncomplicated—4%
- In cases with complications—11%
- In negative appendectomy—10%

29.1.11 Conclusion

Appendicitis may pose a diagnostic dilemma during pregnancy. It is a double-edged sword with increased risk of fetal loss, both when diagnosis is either delayed resulting in perforation or inaccurate resulting in negative appendectomy. A multidisciplinary approach involving a general surgeon, an obstetrician, an anesthetist, and a radiologist is required for accurate pre-operative diagnosis of the condition so as to ensure maximum safety to both the mother and the baby.

29.2 Acute Cholecystitis

29.2.1 Relevant Anatomy of Gallbladder

The gallbladder is a piriform (pear-shaped) organ that occupies the undersurface of segments IVB and V of the liver. The cystic plate separates the gallbladder from the liver parenchyma. Small bile ducts may drain from liver parenchyma directly to the gallbladder through the cystic plate (ducts of Luschka). Fundus of the gallbladder projects beyond the margin and undersurface of right lobe of the liver, it continues into the main body of the gallbladder that lies in a fossa on the undersurface of the liver. Infundibulum is the narrow part of GB that is the continuation of body and it leads through the neck to form the cystic duct which unites with the common hepatic duct to continue as common bile duct (CBD).

The cystic duct has "valves" of Heister which are spiral folds of the mucosa lining the duct. The Hartmann pouch is an inferior outpouching of the gallbladder infundibulum or neck and is present sometimes. The cystohepatic triangle (Fig. 29.2) is formed by the cystic duct on the right, common hepatic duct (CHD) on the left, and undersurface of the liver above. The cystic artery and cystic lymph node of Lund form the contents of this triangle.

The peritoneal fold runs as lesser omentum from the inferior surface of the liver (between the porta hepatis and the umbilical fissure) till the lesser curvature of the stomach and the first part of the duodenum. The free right edge of the lesser omentum is known as the hepatoduodenal ligament.

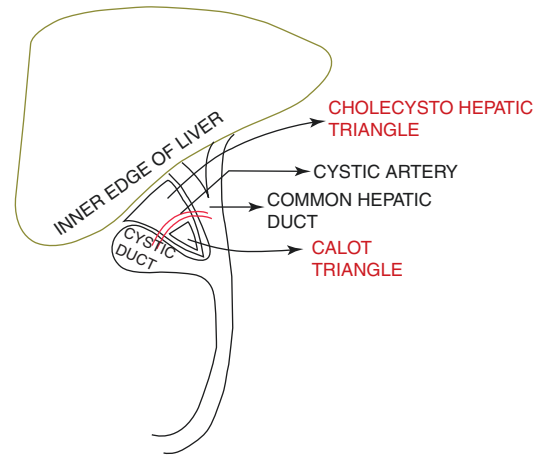

Fig. 29.2 Cystohepatic and Calot's triangle

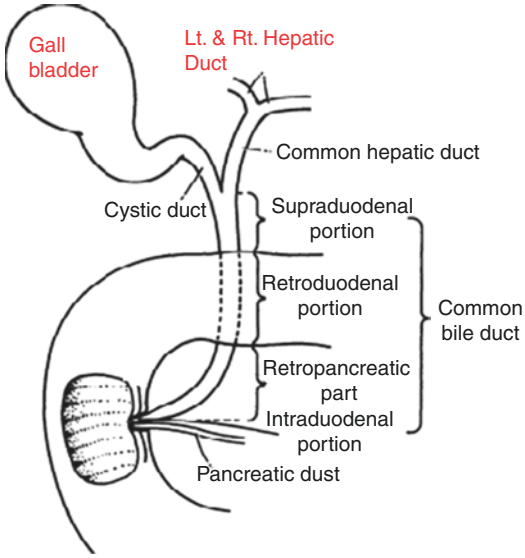

Fig. 29.3 Extrahepatic biliary system showing different parts of CBD

The common bile duct has four parts (Fig. 29.3), namely a supraduodenal, a retroduodenal (behind the first part of the duodenum), an infra-duodenal or retropancreatic (in a groove or sulcus behind or a tunnel through the upper half of the head of the pancreas), and an intraduodenal (intramural) part.

A common channel formed by the terminal parts of CBD and the pancreatic duct runs through the duodenal wall and opens as a nipple like projection on the medial wall of the second part of the duodenum as major papilla.

Sphincter of Oddi, a smooth muscle sphincter, is present around the common channel of the CBD and the main pancreatic duct and prevents reflux of duodenal juice into the two ducts. Two other smooth muscle sphincters, one present around the terminal part of the CBD (sphincter of Boyden) and the other in the terminal part of main pancreatic duct, prevent reflux of pancreatic fluid into the CBD and of biliary secretions into the main pancreatic duct.

Arterial supply: The celiac trunk arises from the anterior surface of the aorta at the level of T12–L1 and divides into the common hepatic artery (CHA), the splenic artery, and the left gastric artery. The CHA gives off the gastroduodenal artery (GDA) and continues as the proper hepatic artery within the hepatoduodenal ligament lying to the right side of the CBD and in front of the portal vein.

The cystic artery is a branch of the right hepatic artery. It divides into an anterior and a posterior branch that supply the gallbladder. Blood supply comes to the gallbladder from the liver via the gallbladder bed also.

There is no named cystic vein but multiple small veins drain the gallbladder into the intrahepatic branches of the portal vein in the liver (segments IV and V); and hence explains the occurrence of bilobar liver metastases.

The lymphatic drainage of gallbladder is via cystic lymph node of Lund along the cystic artery, between the cystic duct and the CHD. Subserosal gallbladder lymphatics also drain into subcapsular lymphatics in liver.

Gallbladder cancer can spread directly to the lymph nodes in the porta hepatis or the hepatoduodenal ligament, without involving the cystic group of lymph nodes therefore refuting the theory of it being the sentinel lymph node.

The gallbladder receives parasympathetic nerve supply from the right vagus through its hepatic branch and sympathetic supply comes from T7 to T9 through the celiac plexus.

Normally gallbladder has a capacity of 30–50 mL but since it acts as a reservoir, its size changes from time to time depending on the volume of bile present in it.

29.2.2 Introduction

Acute cholecystitis is the second most common nonobstetric surgical emergency in pregnancy after acute appendicitis. Pregnancy is associated with increased incidence of gallstone disease due to hormonal changes in estrogen and progesterone. Estrogen causes cholesterol crystal aggregation while progesterone causes bile stasis leading to increased biliary sludge precipitation and gallstone formation. It takes several months after pregnancy to return to normalcy. In addition, obesity and high pre-pregnancy body mass index

are strongly associated with risk of gallstone formation. Like in appendicitis, diagnosis may be delayed due to non-specific signs and symptoms, thereby increasing the risk of complications.

29.2.3 Incidence

Biliary sludge formation (precursor of gallstone) occurs in 30% of pregnancies and gallstone formation occurs in 3% of all pregnancies. Prevalence of gallstone disease is 12.2% in multiparous females versus 1.3% in nulliparous females [15]. Despite predilection for biliary sludge and gallstone formation, acute cholecystitis occurs only in 0.1% of the total pregnancies [16].

29.2.4 Clinical Presentation

Symptoms of acute cholecystitis are usually similar to those that occur in the non-pregnant state and include the classic colicky or stabbing pain in the right upper abdominal quadrant, which can radiate to the inferior angle of right scapula and/or right shoulder. Other symptoms, that may be present, include anorexia, nausea, vomiting, dyspnea, low-grade fever, and fatty food intolerance. Pain usually exacerbates after fatty meal due to the gallbladder contraction which increases the intraluminal pressure secondary to ductal obstruction. Persistence of right upper abdominal pain with low grade fever and vomiting should alarm the treating obstetrician of the possibility of acute cholecystitis.

Physical examination of a patient with acute cholecystitis reveals tenderness in the right upper quadrant of abdomen and a positive Murphy's sign (increase in pain and catch in breath upon abdominal palpation during deep inspiration). Fever and tachycardia suggest an underlying infection. The presence of peritoneal inflammatory signs is extremely ominous, which may reflect either pus formation (empyema) or rupture of the gallbladder.

29.2.5 Pathophysiology

Bacterial invasion is not the primary cause of acute cholecystitis which mainly occurs when the cystic or common bile ducts are obstructed by gallstones. It is the inflammation, hyperemia, and edema of the gallbladder that follow the obstruction and subsequently lead to venous and lymphatic obstruction culminating finally in ischemia. It is only after this secondary ischemia, the bacterial invasion and infection commonly occur [17].

Bactibilia has been reported in up to 65% of women with acute cholecystitis. Conversely, bactibilia is found in 20–30% of patients with biliary concrements that have minimal or no signs of obstruction. E. coli accounts for 75% of all bacterial strains recovered from patients with acute cholecystitis [17].

29.2.6 Diagnosis

Laboratory evaluation may provide assistance in diagnosing the condition but it is clear that management plan will be dictated by the clinical course. Laboratory studies include blood leukocyte count, evaluation of hepatic function, serum bilirubin, amylase, lipase, and alkaline phosphatase. There are numerous alterations in several of these laboratory parameters during pregnancy and this can limit their usefulness. In pregnancy the blood leukocyte count varies from 5000 to 16,000/ml and these values may rise significantly at labor. The liver function tests may not be very helpful in pregnancy as normally also alkaline phosphatase activity (increases two fold during normal pregnancy) and postprandial plasma levels of total bile acids progressively increase during pregnancy. Therefore, laboratory evaluation will only provide clues of affection of biliary tract disease during pregnancy. Common bile duct stones should be suspected if bilirubin remains elevated with persistent jaundice and if there is associated significant leukocytosis, then an underlying infectious process should be considered.

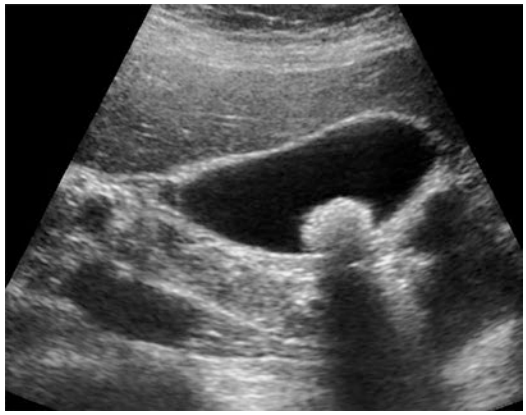

Fig. 29.4 USG showing gallstone with thickened gallbladder wall

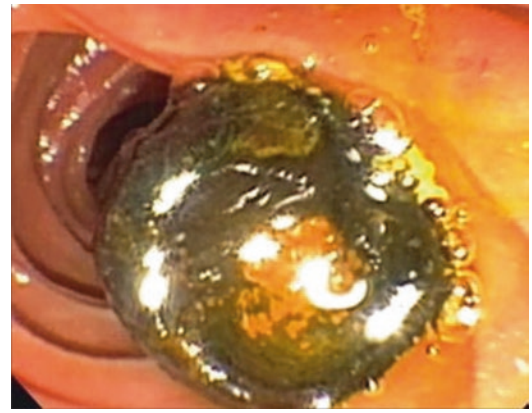

Fig. 29.5 ERCP showing stone in CBD

Ultrasonography: It is the best investigation to diagnose acute cholecystitis in pregnancy as it is cost-effective and non-invasive; with sensitivity of 85–95% and specificity of 95%. Classical findings of acute cholecystitis seen on USG include a thickened gallbladder wall over 3–5 mm, pericholecystic fluid, calculi (Fig. 29.4), and a sonographic Murphy's sign (focal tenderness under the ultrasound transducer positioned over the gallbladder). Few patients may not have typical gallstone on USG evaluation but may show wall echogenic shadow (WES) which is suggestive of either a large gallstone or multiple small gallstones completely filling the lumen of a contracted gallbladder.

MRI and MRCP (Magnetic Resonance Cholangiopancreatography): Magnetic resonance is an imaging modality that can be relied upon to diagnose different etiologies of abdominal pain in any stage of pregnancy [18]. Contrary to the traditional fears, safety of MRCP in pregnancy is approved [19].

ERCP (Endoscopic Retrograde Cholangiopancreatography): It is a useful method to diagnose small stones as well as stones which are present in the ductal system (Fig. 29.5). It has proven to be both diagnostic and therapeutic. ERCP along with sphincterotomy can be used to extract stones and manage pancreatitis by relieving obstruction in common bile duct. The risk of radiation exposure to the fetus from ERCP (approximately 310 mrad) is only theoretical, and is not of concern when conducted after the first trimester [20].

29.2.7 Differential Diagnosis

These include appendicitis, pancreatitis, peptic ulcer disease, pyelonephritis, HELLP syndrome (syndrome of hemolysis, elevated liver enzymes, and low platelets), acute fatty liver, and hepatitis and can be differentiated through blood chemistry and ultrasonography.

29.2.8 Complications

If left untreated, the most dreaded complication is gangrenous cholecystitis. Other serious complications include empyema gallbladder, localized abscess, perforation, internal or external fistula, gallstone ileus, and emphysematous cholecystitis.

29.2.9 Management

Traditionally, conservative approach was used to manage acute cholecystitis in pregnancy as it was accepted that interventions affected gravid uterus and led to increased fetal morbidity and mortality. With advancements made in the fields of

anesthesia, surgery, and obstetrics, an early cholecystectomy by laparoscopic approach is the preferred modality of treatment. Nonoperative management was found to be associated with recurrent attacks, multiple hospital admissions, and complications of the disease resulting in preterm labor, spontaneous abortions, and overall increased fetal morbidity and mortality. The risk of recurrence of symptoms with conservative management if the initial presentation is in first trimester is 92% followed by 64% in second trimester and 44% in the third trimester [21]. Because of high fetal and maternal complication rates, the management of complicated gallstone diseases in pregnancy needs early treatment. Laparoscopic cholecystectomy can be safely performed in pregnancy so as to lower fetal and maternal complications rates.

29.2.9.1 Nonoperative Management

In managing acute cholecystitis in pregnancy, many physicians advocate initial nonoperative management in an effort to prevent effects of surgical intervention's insult on gravid uterus. It includes discontinuation of oral ingestion, intravenous fluid replacement, analgesia, and administration of antibiotics. As spasm of sphincter of Oddi is caused by morphine and its derivatives, these should be avoided as analgesics in pregnant females. Among commonly used antibiotics, the combination of a penicillin and an aminoglycoside has long been recommended as the initial treatment of choice for these patients. This broad spectrum antibiotic therapy is initiated empirically and is based on the bacterial flora likely to be encountered in the biliary tract. While penicillin offers adequate coverage against gram-positive organisms along with most of the anaerobes and enterococcus species, aminoglycosides act against gram-negative facultative biliary pathogens including Pseudomonas. Due to the rising concern about aminoglycoside-induced nephrotoxicity, especially in patients with jaundice and sepsis, cephalosporins have potentially come in use in place of penicillin plus aminoglycoside. On reviewing the efficacy of cefepime in patients of acute cholecystitis, it was found that its single drug therapy was as effective as combination therapy with mezlocillin and gentamicin [22]. Cefepime requires 12 h dosing to achieve high bile, blood, and gallbladder levels. Piperacillin, an extended spectrum penicillin, has been shown to be effective in patients with acute cholecystitis and it has broad coverage against all organisms commonly found in the biliary tract, with excellent biliary excretion and negligible nephrotoxicity.

29.2.9.2 Minimally Invasive Procedures

In selected high-risk patients where medical management has failed and operative interventions pose serious operative risks, less invasive procedures such as percutaneous transhepatic gallbladder drainage (PTGBD) and ERCP can be performed to combat the acute inflammatory phase, decrease the infectivity, and enable patient to better tolerate any definitive surgery. USG guided PTGBD provides adequate biliary decompression and has been shown to be safe and temporarily effective in treating acalculous cholecystitis [23]. It is recommended that the drainage tube should not be removed until a mature fistulous tract forms around it (around 2 weeks). Major disadvantages associated with this procedure are bile leakage, bile duct injury, and abdominal abscess [24]. When CBD stones are considered to be the offending cause of acute cholecystitis, ERCP and generous sphincterotomy should be performed with an aim of subsequent removal of the stone [25].

29.2.9.3 Surgical Management

All attempts must be made to defer surgical intervention on a patient in her first trimester until the second trimester, and of a patient in the third trimester, try to postpone until after parturition. Fetal organogenesis is complete by the second trimester and the size of the gravid uterus also allows relatively good visualization of operative field. With advances in laparoscopic surgery in pregnancy, it has been safe to use open Hasson trocar method for inserting first port into the abdominal cavity; to prevent injury to the gravid uterus [26]. Pneumoperitoneum should be kept at a maximum pressure of 12 mmHg and fetal well-

being should be monitored continuously with transvaginal ultrasound. Laparoscopic surgery has advantageous end results of a shorter hospital stay, smaller incision, and early ambulation. Patients undergoing open cholecystectomy experience a higher frequency of postoperative premature uterine contractions requiring tocolytic therapy compared to those undergoing laparoscopic cholecystectomy, resulting in lesser need of open intervention [27].

29.2.10 Prognosis

Perinatal outcomes among patients with acute cholecystitis treated conservatively [28] are as follows:

- Preterm delivery—3.4%
- Missed abortion—1.7%
- Low birth weight—5%
- Maternal death—1.7%.

Perinatal outcomes among patients with acute cholecystitis treated surgically [28] are:

- Preterm delivery—3.4%
- Low birth weight—3.4%.

29.2.11 Conclusion

Biliary tract disease in pregnancy is relatively an uncommon occurrence. Progression to acute cholecystitis can be difficult to recognize due to the heterogeneous nature of the disease. Once appropriately diagnosed, the initial management consists of conservative approach which includes institution of antibiotic therapy along with analgesics and IV fluids. Depending on the gestational age at diagnosis, the further management plan may differ. Surgical intervention, when indicated, should not be delayed as this could lead to deleterious effects on both fetus and the mother. A planned intervention done in second trimester appears to offer a better outcome than surgery performed under emergent conditions.

29.3 Intestinal Obstruction

29.3.1 Relevant Anatomy

29.3.1.1 The Small Intestine

The small bowel lies between the stomach and the large intestine. It includes the duodenum, jejunum, ileum, and proximal colon. Embryologically, it develops from midgut, with the superior mesenteric artery (SMA) as its arterial supply. It is during the early stages of development that the midgut communicates with the yolk sac via the vitellointestinal (omphalomesenteric) duct but then subsequently returns to the abdominal cavity to occupy the normal anatomical position after completing its 270° rotation.

29.3.1.2 The Large Intestine

The proximal part of large intestine develops from the midgut (from cecum to proximal 2/3rd transverse colon) whereas the distal part develops from the hindgut (from distal ⅓ transverse colon to dentate line in anorectum), and proctoderm (below the dentate line). It derives its arterial supply from both superior and inferior mesenteric arteries (SMA & IMA).

Variation in anatomy such as malrotation of gut, Ladd's band, persistence or patency of vitellointestinal duct, etc. may predispose a person for development of intestinal obstruction.

29.3.2 Introduction

Intestinal obstruction is a rare but serious surgical condition. Its incidence is reported to be similar in pregnant and non-pregnant females varying between 1 in 1500 pregnancies to 1 in 66,431 pregnancies [29]. It causes high maternal mortality (6–20%) as well as fetal mortality (20–26%) [30]. The commonest cause of intestinal obstruction in pregnancy is adhesions, accounting for around 60% of the cases. Some of the other causes include sigmoid volvulus (25%), intussusception (5%), stricture, hernia, carcinoma, and diverticulitis/diverticulosis [31].

Adhesions account for 6, 27, 44, and 21% of the intestinal obstruction rates seen during the first, second, and third trimester of pregnancy and postpartum respectively.

Delay in diagnosis can lead to intestinal strangulation, further increasing the incidence of maternal morbidity, mortality, premature labor, and fetal loss. Therefore, early recognition of the disorder and prompt initiation of treatment is mandatory [32].

29.3.3 Pathophysiology

Intestinal obstruction can be either dynamic or adynamic. In dynamic type, peristalsis occurs against a mechanical obstruction, e.g. stricture/adhesions whereas in adynamic type, there is no mechanical obstruction but there is absent/decreased peristalsis leading to bowel stasis, e.g. paralytic ileus. Dynamic intestinal obstruction is further classified into small bowel obstruction (high/low) and large bowel obstruction.

One of the hypotheses in favor of intestinal obstruction manifesting in pregnancy is that due to distortion in relationship between various organs as a result of enlarging gravid uterus, previous asymptomatic adhesions may stretch and precipitate compression upon the adjoining intestine.

29.3.4 Clinical Features

The cardinal symptoms of intestinal obstruction in pregnancy include abdominal pain (98%), vomiting (82%), and obstipation (30%). Abdominal tenderness and increased abdominal peristalsis are observed in 71 and 55% of the patients, respectively [33]. The sequence of appearance of symptoms varies according to the site of obstruction. In case of small bowel obstruction, vomiting precedes obstipation whereas in case of large bowel obstruction obstipation along with pain abdomen is the most common presenting complaint. Vomiting, in case of large bowel obstruction, may not be present in patients presenting early in the course of disease. Pregnant females usually have 'morning sickness' in the first trimester of pregnancy, which can be misinterpreted as intestinal obstruction. Nausea in morning sickness is sometimes accompanied by vomiting (non-bilious in nature) and occurs in the morning only whereas any pregnant lady with persistent and progressive bilious vomiting should be evaluated for intestinal obstruction especially when she has had a history of surgery before—as she is more likely to have developed adhesions resulting from that past surgery. Also, increasing abdominal girth in obstruction may be attributed to enlarging uterus due to advancing pregnancy. In addition, stretched anterior abdominal wall becomes less sensitive to parietal peritoneal irritation (which is the cause for pain) & may delay the diagnosis of precipitating complications.

29.3.5 Diagnosis

Blood investigations: TLC is normally elevated in pregnancy due to increased adrenocortical activity. Serial WBC counts are more useful to arrive at a diagnosis in pregnancy. Serum electrolytes and KFT may also predict the cause and effect of obstruction. Hypokalemia and hypocalcemia are very important causes of adynamic obstruction which can be easily ruled out by performing serum electrolyte analysis. Conversely, in small bowel obstruction patients may develop hypokalemia secondary to persistent vomiting.

Arterial blood gas (ABG) is another necessary investigation that helps in diagnosing intestinal strangulation early in the course of disease. It calculates lactate levels which are raised in case of strangulation.

Ultrasonography(USG): It is used as an initial investigation and shows dilated bowel loops with to and fro movement of the dilated loop along with some free fluid in the abdomen suggestive of dynamic bowel obstruction. When there is absence of this to and fro movement but the bowel is dilated, then one must think either of adynamic obstruction or late stage of dynamic

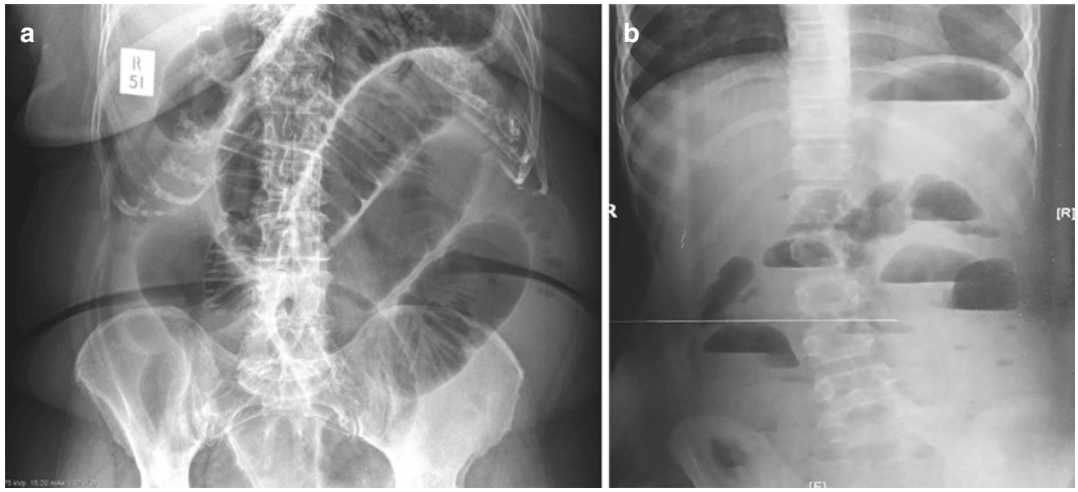

Fig. 29.6 (**a**) Step ladder pattern in case of small intestine obstruction. (**b**) Centrally placed multiple air fluid levels, classical of small intestinal obstruction

obstruction with bowel fatigue. Apart from diagnosing the condition, it also helps to follow the course of a conservative treatment; it will suggest for laparotomy in case a thickened intestinal wall, reflecting an ischemia, is seen. It also eliminates the other causes of ileus, viz. biliary and renal origin. It is the only investigation that specifies fetal or embryonic viability.

X-ray: In case USG is inconclusive, X-ray abdomen may be required to make definitive diagnosis (Fig. 29.6a and b). The United States National Council on Radiation Protection considers exposure of 5 cGy or less to be negligible, in causing harm to the fetus, compared with other risks of pregnancy [34]. If essential, diagnostic abdominal X-ray in the pregnant women can be done with an acceptable risk in the appropriate setting.

Computed tomography (CT): It remains the gold standard for the diagnosis of intestinal obstruction. However, it is contraindicated in phase of organogenesis during pregnancy because of detrimental effects from high doses of irradiation. But recent data suggests that noncontrast CT scan can be safer in diagnosing intestinal obstruction in pregnant females with very little chances of fetal damage, especially when other modalities of diagnosis have failed to give a concrete answer [35].

Magnetic Resonance Imaging: MRI provides large field-of-view images of maternal abnormalities with excellent soft-tissue delineation. It also allows the pancreatic and biliary ducts, blood vessels, and genitourinary tract to be visualized without the intravenous administration of a contrast agent. MRI also does not expose the fetus to ionizing radiation and aids in diagnosis even without the need for the intravenous administration of contrast material. It can be used to evaluate a pregnant lady presenting with abdominal symptoms, to delineate the anatomy and to exclude a variety of patient's pathological processes that may give rise to small bowel obstruction [36].

29.3.6 Management

In the absence of signs of peritonitis, a conservative approach should be tried initially, which includes monitoring vital parameters, abdominal girth monitoring, nasogastric aspiration, supplementation of intravenous fluids, and analgesics. This relieves majority of the patients of their symptoms and prevents unnecessary manipulations that could have detrimental effects on pregnancy. Surgical intervention is indicated when conservative therapy fails even

after 48–72 h of observation and when signs of impending bowel strangulation or symptoms of fetal distress set in. To decrease the risk of premature uterine contractions, tocolytic agents are administered prophylactically, especially when surgery is contemplated or complications occur. In the third trimester, if adequate exposure of intestine cannot be obtained, cesarean section must be performed and laparotomy is continued [37]. The entire bowel must be examined for other areas of obstruction and viability. Segmental resection with anastomosis or exteriorization of proximal segment (as stoma) may be necessary in the presence of gangrenous bowel. In pregnant women having inadequate oral intake, underlying disease states requiring complete bowel rest or severe illness should be treated with intravenous hyperalimentation (TPN). TPN might benefit the fetus by promoting intrauterine growth in cases involving fetal growth retardation due to severe maternal nutritional deprivation.

Although majority of the patients are initially managed conservatively, definitive treatment of conditions causing dynamic obstruction is surgery, which is to be undertaken after proper resuscitation to decrease maternal and fetal morbidity and mortality. Preferably, definitive procedures are generally postponed until after delivery, if possible, or else they are performed under calculated risk after proper informed consent.

29.3.7 Prognosis

Maternal mortality increased from 20 to 31% in 1958 but subsequently it has decreased to 6%, or even zero at present, because of the progress made in resuscitative measures taken at right time [38]. However, fetal mortality remains static between 20 and 30%; prematurity and fetal hypoxia secondary to maternal hypotension being the harbingers [38]. Fetal mortality also varies with respect to age of gestation: none in the first trimester & reaching 36 and 64% in the second and third trimesters, respectively [39].

29.3.8 Conclusion

Onset of intestinal obstruction in pregnancy is rare and distension, which is not differentiated easily, delays the diagnosis. Maternal morbidity and fetal mortality remain high though early diagnosis and prompt treatment improves prognosis. Conservative treatment, besides aiding in relieving the obstruction, helps to prepare the patient to bear the surgical trauma better.

29.4 Hernia in Pregnancy

29.4.1 Introduction

Hernia is one of the rare nonobstetric surgical problems encountered in pregnant females. Primary ventral hernias are usually either umbilical or epigastric. Among groin hernias, inguinal and femoral hernias occur in a ratio of 5:1. Prevalence of primary ventral hernia in pregnancy is unknown but pregnancy is a known risk factor for recurrence of hernia after primary repair. Also, the evidence for surgical strategy in pregnant women with a hernia is limited and is only reported in a limited number of case reports. The data on risk of hernia incarceration or strangulation during pregnancy and planning of subsequent elective repair are also unknown.

29.4.2 Incidence

Incidence of inguinal hernia during pregnancy is reported to be 1:1000–3000. Out of all the inguinal hernias occurring in pregnancy, 75% occur in multipara pregnancies, suggesting that the increased intra-abdominal pressure and related hormonal changes during pregnancy predispose a female to develop inguinal hernia [40].

29.4.3 Classification of Hernia

Hernias are categorized according to the site of origin and the contents present in the hernial sac. (Table 29.3).

Table 29.3 Classification of hernia

According to region	Ventral hernia	Umbilical–paraumbilical Epigastric Incisional Parastomal Spigelian Lumbar Traumatic
	Inguinal hernias	Direct inguinal hernia Indirect inguinal hernia
	Femoral hernia	
	Lumbar hernia	Superior lumbar hernia Inferior lumbar hernia
	Rare external hernias	Perineal hernia Obturator hernia Gluteal and sciatic hernia
	Diaphragmatic hernias	Bochdalek hernia Anterior Morgagni's Hiatus hernia
According to Contents	Omentocele—omentum Enterocele—intestine Cystocele—urinary bladder Litter's hernia—Meckel's diverticulum Maydl's hernia—Sliding hernia Richter's hernia—part of the bowel wall forms the content of hernial sac Amyand hernia—containing appendix as a content in inguinal hernial sac De Garengeot—appendix in femoral hernia sac	

Fig. 29.7 Right indirect inguinal hernia

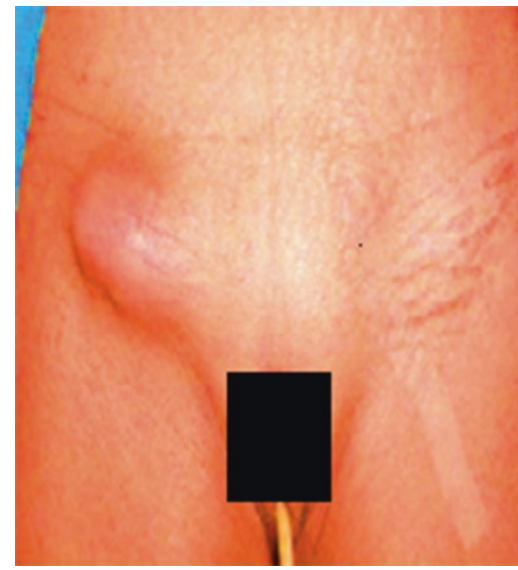

Fig. 29.8 Right femoral hernia

29.4.4 Types of Hernias Common in Pregnancy

29.4.4.1 Groin Hernia

These can be direct inguinal hernia, indirect inguinal hernia (Fig. 29.7), or femoral hernias (Fig. 29.8). The risk factor for development of inguinal hernias are same as for the general population, i.e. family history of inguinal hernia, collagen disorders, smoking, renal failure, chronic lung disease, diabetes mellitus, long-term steroid use, malignancy, malnutrition, cirrhosis, ascites, and obesity. Adding to these factors, increase in intra-abdominal pressure due to an enlarging pregnant uterus has also been postulated to play some role.

Recurrence after hernioplasty can be secondary to deep infection, undue tension on the repair site, or tissue ischemia, leading to wound dehiscence, as is seen in non-pregnant patients. Majority of the cases can be managed by elective surgery. Possible reasons for the high rate of

emergency operations during pregnancy, particularly in femoral hernias, are ignoring the asymptomatic hernias prior to their getting incarcerated and difficulties in diagnosis.

29.4.4.2 Umbilical Hernia

The herniation occurs typically at the umbilicus (Fig. 29.9), but paraumbilical are also frequent; in some cases, it may be either above (supraumbilical) or below umbilicus (infraumbilical). The defect is covered directly by skin without any underlying fat.

Mostly, the cause is attributable to a weakness of the abdominal wall or an increase in abdominal pressure (as occurs in pregnancy), cirrhosis, or obesitiy [41]. These hernias show slow enlargement over a period of years and chances of subsequent strangulation are much more as compared to that occurring in pediatric umbilical hernias. Diagnosis is primarily clinical, based on definitive evidence of dilated umbilical ring, with or without contents in the hernia sac. If incarceration is present, symptoms depend on the organ affected and its duration. Strangulated bowel causes intense pain, vomiting, distension and obstipation; uterine fibroid or greater omentum when strangulated causes only pain and local tenderness. If the bowel present in the hernia sac becomes necrotic or if perforation ensues, the surrounding tissue and the overlying skin of the abdominal wall become erythematous and edematous. Abdominal ultrasound can be used for diagnosis in doubtful cases. Differential diagnosis of strangulated umbilical hernia includes omphalitis and periumbilical abscess. One of the differential diagnoses of umbilical hernia is postoperative hernia after laparoscopic surgery occurring through supra or infraumbilical port site incisions which can easily be differentiated by history taking and evidence of surgical scars. Both suturing and mesh can be used for repair, the latter having a significantly lower recurrence rate [42].

Fig. 29.9 Umbilical hernia in distended abdomen due to pregnancy

29.4.4.3 Incisional Hernia

The overall incidence of postoperative hernia in pregnancy is unknown. Following cesarean section, it is around 3% and is commonly associated with midline incisions, the number of additional operative procedures, occurrence of postoperative abdominal distension, intra-abdominal sepsis, intra-abdominal abscess, wound dehiscence, and postoperative fever [43]. History of previous abdominal surgery, signs and symptoms [bulge at or around the scar (Fig. 29.10), obstruction—abdominal pain, vomiting, non-passage of flatus and stool] and physical examination (abdominal wall scars of previous surgery, with palpable defect in the abdominal wall and distension) are

Fig. 29.10 Incisional hernia

sufficient for the diagnosis. If in doubt, ultrasound examination can be done to define hernial sac and its contents. Rarely, a gravid uterus can herniate into anterior abdominal wall through an incisional hernia and lead to serious obstetric consequences including strangulation, abortion, premature labor, accidental hemorrhage, intrauterine death, and rupture of the lower uterine segment [44, 45]. Strict monitoring of affected pregnant woman and her fetus is necessary because the uterus in an abdominal wall hernia can interfere with fetal growth and may cause intrauterine growth restriction. The management in emergent conditions depends mainly on the gestational age at presentation. If the uterus is strangulated early in pregnancy, termination of pregnancy with immediate anatomical repair of the hernial defect should be undertaken. If it occurs at or near term, emergency laparotomy, cesarean section delivery, followed by immediate repair of the hernia is recommended. The best method of repair is mass closure [closure of all the layers of the abdominal wall (except the skin) as one structure] using wide bites with the sutures sufficiently close together so as to comply with Jenkin's rule which declares the need for use of four times the length of suture material as the length of the wound [46]. Mesh closure is better than suturing the defect, if an incisional hernia is operated before planned pregnancy; but development of recurrence is a definite possibility which may be a factor to favor suturing till the family is completed and then repair of hernia can be undertaken by mesh placement.

29.4.4.4 Parastomal Hernia

A parastomal hernia is a type of incisional hernia that is related to an abdominal wall stoma. The principles of diagnosing and treating these hernias are the same as in non-pregnant patients. Ileostomy, urostomy, and colostomy are the three types of ostomies commonly seen in pregnant women with ileostomy being the most frequent. Some degree of parastomal herniation is considered to be almost inevitable. As parastomal hernias frequently obstruct, their diagnosis is difficult to be made in a pregnant patient because the symptoms of nausea, vomiting, and constipation can be seen normally in pregnancy. Examination should be performed both in standing and supine position wherein hernia appears as a bulge around the stoma. Digital examination of the stoma enables assessment of fascial aperture and parastomal tissue and local tissue strength. If history is suggestive of a hernia but it is not evident clinically, then ultrasound or computed tomography (CT) should be advised to detect even subclinical hernias. Surgical options for correcting the condition include peristomal hernia repair and stomal transposition with or without mesh repair.

29.4.5 Diagnosis

Majority of the patients with abdominal wall hernias can be easily diagnosed clinically but few subclinical cases or those presenting with atypical features need additional radiological and biochemical investigations.

29.4.5.1 Blood Investigations

These are necessary to aid in ruling out strangulation or obstruction. Baseline blood investigations along with ABG (arterial blood gases) are the minimum blood investigations required while managing the above conditions.

29.4.5.2 USG

It is a non-invasive imaging modality that does not use radioactive substance and has no harmful effects on fetus. This can be safely used in cases with doubtful diagnosis. Ultrasonography can be included in the diagnostic assessment of a pregnant woman with a bulge in the groin. Round ligament varicosities constitute a differential diagnosis to inguinal and femoral hernia [47, 48].

29.4.5.3 CT Scan

It is not used routinely in diagnosing uncomplicated hernias but has been used, at low radiation dose, in complicated cases without significant effects on fetal health.

29.4.5.4 MRI

MRI as a diagnostic tool in cases of hernias has a limited role. It has been used in cases of interstitial hernias due to their lack of clarity & obvious physical findings. It has also been used in diagnosing atypical cases in the first trimester so as to avoid CT which is known to carry a radiation risk, how so ever small or mere theoretical, on fetal development.

29.4.6 Treatment

Watchful waiting during pregnancy with a plan for repair post-delivery is the ideal treatment modality that is being followed by majority of surgeons. A groin bulge may resolve in several patients after childbirth with less than one-fifth patients needing formal postpartum repair. In a pregnant lady with uncomplicated reducible hernias, it has been found that recommending watchful waiting is safe and cost-effective for both primary ventral and groin hernia, and perform surgical repair if symptoms persist after delivery.

Conservative measures including weight control, the avoidance of heavy weight lifting, stool softeners, and abdominal binders are used in uncomplicated cases.

Abdominal wall hernia repair can be done concomitantly with cesarean section as the current literature suggests no increased risk of severe perioperative complications. Moreover, a combined procedure saves the patient from an additional operative procedure that will need to be performed at a later date.

In case of a hernia in the infraumbilical region, where concomitant hernia repair is being planned, the incision of choice for cesarean section should be Pfannenstiel, due to the low risk of complications such as incisional hernia [49]. Furthermore, repair of hernias with a large cranio-caudal fascial defect should be undertaken through cranio-caudal incision. In case of groin hernias in women, it is generally advised to place a preperitoneal mesh due to the risk of overlooking a femoral hernia [50]. This should also be undertaken for repair concomitant to cesarean section.

Repair of small umbilical or paraumbilical hernias under local anesthesia is feasible and it imposes no anesthetic risk to the fetus. When using regional anesthesia, spinal anesthesia is preferred over epidural or combined spinal-epidural, as it offers the least drug transfer for the degree of anesthesia achieved [51]. The need for sedation or general anesthesia is greater in a pregnant woman because of the tension created by the gravid uterus. Maternal risk with general anesthesia during obstetric delivery is well documented, with a mortality risk ratio 16.7 times that for regional anesthesia [52]. Fetal risk with anesthesia is less clear and there is no clear evidence that any anesthetic agent is a definite human teratogen [52, 53]. The repair of umbilical, inguinal, and ventral hernias during pregnancy is indicated only in the event of an incarceration or strangulation [52].

29.4.7 Pregnancy, Hernia Recurrence, and Recommendations for Repair

Since pregnancy causes an increased risk of abdominal hernia recurrence, the same should be conveyed to the patients who are planning to undergo an elective hernia repair before a subsequent gestation. A mesh repair, though ideal, may restrict the flexibility of the anterior abdominal wall (due to dense fibrosis induced by mesh) and may lead to increased pain during a subsequent pregnancy [54]. Hence suture repair is to be undertaken, when indicated, till the family commitments get completed. Formal mesh herniorrhaphy can then be undertaken, which will avoid the pregnancy stresses to play upon the hernia repair causing it to break down leading to increased chances of recurrences.

Having said about the options and methods of treating different types of hernias, till date there are no clinical or experimental studies that could dictate the adequate time interval between hernia repair and pregnancy. Although a gap of minimum 1 year is advised by most of the surgeons, there is no consensus on whether this 1-year

interval ends after beginning of the pregnancy or after the time of birth. *We would recommend that the patients should be counseled to conceive and proceed on their family way after a period of minimum 1 year following repair of hernia and further delay of couple of years more, if no contradictions are there.*

With all the evidence available, it can be concluded that mesh repair of ventral hernia and inguinal hernias appears to be a safe in pregnant women with no significant impact on pregnancy and labor course [55, 56]. Also, hernia repair with mesh is preferred in women who have not completed their family yet as it has no significant effect on future pregnancy and course of labor. *Yet, we would recommend primary suture repair of small hernias over mesh supplementation; the latter being reserved for larger and recurrent hernias or when the patient has completed her family.*

29.5 Conclusion

Abdominal wall hernias which are rare during pregnancy can present for the first time during pregnancy or become clinically worse during pregnancy. Hernias during pregnancy are usually asymptomatic or have minimal symptoms. Such hernias need to be managed as in non-pregnant females. Conservative measures including weight control, the avoidance of heavy lifting, stool softeners, and abdominal binders are used in uncomplicated cases. Definitive repair should be done deferred till delivery and complete uterine involution so as to prevent possible hernia-related complications during normal daily activities or later pregnancies. If patients present with hernias before a planned pregnancy, then these should be repaired to avoid possible complications during gestation. It is of utmost importance to diagnose emergent situations such as incarceration (obstruction), strangulation, and perforation because these affect both mother and the fetus. There is still no consensus on undertaking repair of irreducible hernia during pregnancy, but potential surgical effects upon pregnancy would favor to undertake an elective operation after pregnancy is over. Also, hernioplasty is recommended during pregnancy, especially in early gestation, to avoid complications that are likely to occur with advancing pregnancy.

Key Points

- Acute appendicitis is the most common nonobstetric surgical condition encountered during pregnancy.
- Physiological changes in pregnancy including uterine growth pose great challenge in timely diagnosis of the condition in pregnant women. Alvarado score combined with CRP and RIPASA score have emerged as very useful tools to diagnose acute appendicitis with good results even in pregnant females.
- Appendicectomy in pregnant females has similar morbidity and mortality as in non-pregnant females; the risk is greater for the fetus.
- Acute cholecystitis is the second most common nonobstetric surgical emergency in pregnant females after acute appendicitis.
- Diagnosis may be delayed due to nonspecific signs and symptoms. History, clinical examination along with noninvasive investigation like ultrasound are still the most common method of diagnosing acute cholecystitis.
- With advancement in the field of anesthesia, surgery, and obstetrics, an early cholecystectomy by laparoscopic approach is the preferred modality of treatment.
- Intestinal obstruction is a rare but serious surgical condition encountered during pregnancy and delay in diagnosis due to overlapping signs and symptoms may lead to increased chances of strangulation which in turn causes higher maternal morbidity and mortality, premature labor, and fetal loss.
- Diagnosis of intestinal obstruction is aided by clinical examination and inves-

tigations like ultrasound, low dose NCCT, and MRI (during the period of organogenesis).
- Management of intestinal obstruction is mainly conservative until there are ominous signs suggestive of failure of conservative therapy or development of complications.
- Incidence of inguinal hernia in pregnancy is reported to be 1:1000–3000 with majority seen in multiparous women.
- Increased intra-abdominal pressure combined with pregnancy related hormonal changes have been postulated to be the etiological factors predisposing a pregnant woman for developing a hernia.
- Diagnosis is predominantly clinical; albeit few exceptions when a non-invasive investigation like ultrasound is used to diagnose the condition in females presenting with atypical features.
- Watchful waiting during pregnancy with a plan for postpartum repair is the ideal treatment modality; definitive repair of hernias is to be done after spontaneous delivery and uterine involution, to prevent possible hernia-related complications.

Acknowledgement We are thankful to Dr. Kiranpreet Kaur for her assistance in text compilation and formatting and Mr. Sahil Juneja for the diagram of different positions of appendix.

References

1. Schumpelick V, Dreuw B, Ophoff K, et al. Appendix and cecum. Embryology, anatomy, and surgical applications. Surg Clin North Am. 2000;80:295–318.
2. Arda IS, Şenocak ME, Hiçsönmez A. Duplication of vermiform appendix: case report and review of the literature. Pediatr Surg Int. 1982;7:221–2.
3. Uriev, Leonid, Maslovsky, et al. Triple-barreled type of appendiceal triplication. Ann Diagn Pathol. 2005;10:160–1.
4. Kahai P, Mandiga P, Wehrle CJ, et al. StatPearls. Treasure Island, FL: StatPearls Publishing; 2020.
5. Zingone F, Sultan AA, Humes DJ, et al. Risk of acute appendicitis in and around pregnancy: a population-based cohort study from England. Ann Surg. 2015;261:332–7.
6. Babaknia A, Parsa H, Woodruff JD. Appendicitis during pregnancy. Obstet Gynecol. 1977;50:40–4.
7. McGory ML, Zingmond DS, Tillou A, et al. Negative appendectomy in pregnant women is associated with a substantial risk of fetal loss. J Am Coll Surg. 2007;205:534–40.
8. Mantoglu B, Gonullu E, Akdeniz Y, et al. Which appendicitis scoring system is most suitable for pregnant patients? A comparison of nine different systems. World J Emerg Surg. 2020;15:34.
9. Khandelwal A, Fasih N, Kielar A. Imaging of acute abdomen in pregnancy. Radiol Clin N Am. 2013;51:1005–22.
10. Parks NA, Schroeppel TJ. Update on imaging for acute appendicitis. Surg Clin North Am. 2011;91:141–54.
11. Fatum R, Rojansky N. Laparoscopic surgery during pregnancy. Obstet Gynecol Surv. 2001;56:50–9.
12. Korndorffer JR, Fellinger E, Reed W. SAGES guideline for laparoscopic appendectomy. Surg Endosc. 2010;24:757–61.
13. Guidelines Committee of the Society of American Gastrointestinal and Endoscopic Surgeons. Yumi H. Guidelines for diagnosis, treatment, and use of laparoscopy for surgical problems during pregnancy: this statement was reviewed and approved by the Board of Governors of the Society of American Gastrointestinal and Endoscopic Surgeons (SAGES), September 2007. It was prepared by the SAGES guidelines committee. Surg Endosc. 2008;22:849–61.
14. Liu PL, Warren TM, Ostheimer GW, et al. Fetal monitoring in parturients undergoing surgery unrelated to pregnancy. Can Anaesth SocJ. 1985;32:525–32.
15. Mendez-Sanchez N, Chavez-Tapia NC, Uribe M. Pregnancy and gallbladder disease. Ann Hepatol. 2006;5:227–30.
16. Dietrich CS, Hill CC, Hueman M. Surgical diseases presenting in pregnancy. Surg Clin North Am. 2008;88:408–19.
17. Stauffer RA, Adams A, Wygal J, et al. Gallbladder disease in pregnancy. Am J Obstet Gynccol. 1982;144:661–5.
18. Tuech JJ, Binelli C, Aube C, et al. Management of choledocholithiasis during pregnancy by magnetic resonance cholangiography and laparoscopic common bile duct stone extraction. Surg Laparosc Endosc Percutan Tech. 2000;10:323–5.
19. Shellock FG, Kanal E. Policies, guidelines, and recommendations for MR imaging safety and patient management. SMRI safety committee. J Magn Reson Imaging. 1991;1:97–101.

20. Kahaleh M, Hartwell GD, Arseneau KO, et al. Safety and efficacy of ERCP in pregnancy. Gastrointest Endosc. 2004;60(2):287–92.
21. Jackson H, Granger S, Price R, et al. Diagnosis and laparoscopic treatment of surgical diseases during pregnancy: an evidence-based review. Surg Endosc. 2008;22:1917–27.
22. Yellin AE, Berne TV, Appleman MD, et al. A randomized study of cefepime versus the combination of gentamicin and mezlocillin as an adjunct to surgical treatment in patients with acute cholecystitis. Surg Gynecol Obstet. 1993;177(Suppl):23–9; discussion 35–40
23. Allmendiger N, Hallisey MJ, Ohki SK, et al. Percutaneous cholecystostomy treatment of acute cholecystitis in pregnancy. Obstet Gynecol. 1995;86:653–4.
24. Tsumura H, Ichikawa T, Hiyama E, et al. An evaluation of laparoscopic cholecystectomy after selective percutaneous transhepatic gallbladder drainage for acute cholecystitis. Gastrointest Endosc. 2004;59:839–44.
25. Angelini DJ. Obstetric triage: management of acute non-obstetric abdominal pain in pregnancy. J Nurse Midwifery. 1999;44:572–84.
26. Halkic N, Tempia-Caliera AA, Ksontini R, et al. Laparoscopic management of appendicitis and symptomatic cholelithiasis during pregnancy. Langenbeck's Arch Surg. 2006;391:467–71.
27. Barone JE, Bears S, Chen S, et al. Outcome study of cholecystectomy during pregnancy. Am J Surg. 1999;177:232–6.
28. İlhan M, İlhan G, Gök AF, et al. The course and outcomes of complicated gallstone disease in pregnancy: experience of a tertiary center. Turk J Obstet Gynecol. 2016;13:178–82.
29. Perdue PW, Johnson HW, Stafford PW. Intestinal obstruction complicating pregnancy. Am J Surg. 1992;164:384–8.
30. Coleman MT, Trianfo VA, Rund DA. Nonobstetric emergencies in pregnancy: trauma and surgical conditions. Am J Obstet Gynecol. 1997;177:497–502.
31. Connolly MM, UntiJA NPF. Bowel obstruction in pregnancy. Surg Clinical North Am. 1995;75:101.
32. Watanabe S, Otsubo Y, Shinagawa T, et al. Small bowel obstruction in early pregnancy treated by jejunotomy and total parenteral nutrition. Obstet Gynecol. 2000;96:812–3.
33. Zachariah SK, Fenn MG. Acute intestinal obstruction complicating pregnancy: diagnosis and surgical management. BMJ Case Reports. 2014:bcr2013203235.
34. Martin RH, Perry KG, Morrison J. Surgical disease and disorders in pregnancy in: De Chemey AH, Pemoll ML, eds. Current obstetrics & Gynecology diagnosis & treatment 2ndnd ed. Appleton & Lange Norwalk: 1994:493.
35. Patel SJ, Reede DL, Katz DS, et al. Imaging the pregnant patient for nonobstetric conditions: algorithms and radiation dose considerations. Radiographics. 2007;27:1705–22.
36. Leyendecker JR, Gorengaut V, Brown JJ. MR imaging of maternal diseases of the abdomen and pelvis during pregnancy and the immediate postpartum period. Radiographics. 2004;24:1301–16.
37. Redlich RS, Costa SD, Wolff S. Small bowel obstruction in pregnancy. Arch Gynecol Obstet. 2007;275:381–3.
38. Najih M, Abdellaoui M, Hafidi MR, et al. Acute pelvic inflammatory occlusion in five cases. Pan Afr Med J. 2012;11:40.
39. Twité N, Jacquet C, Hollemaert S, et al. Bowel obstruction and pregnancy. Rev Med Brux. 2006;27:104–9.
40. Simchen E, Wax Y, Galai N, et al. Differential effect of risk factors on early and late wound infections in patients undergoing herniorrhaphies. Ann Epidemiol. 1992;2:263–72.
41. Muschaweck U. Umbilical and epigastric hernia repair. Surg Clin North Am. 2003;83:1207–21.
42. Sanjay P, Reid TD, Davies EL, et al. A retrospective comparison of mesh and sutured repair for adult umbilical hernias. Hernia. 2005;9:248–51.
43. Adesunkanmi AR, Faleyimu B. Incidence and aetiological factors of incisional hernia in post-caesarean operations in a Nigerian hospital. J Obstet Gynaecol. 2003;23:258–60.
44. Malhotra M, Sharma JB, Wadhwa L, et al. Successful pregnancy outcome after cesarean section in a case of gravid uterus growing in an incisional hernia of the anterior abdominal wall. Indian J Med Sci. 2003;57:501–3.
45. Deka D, Banerjee N, Takkar D. Incarcerated pregnant uterus in an incisional hernia. Int J Gynecol Obstet. 2000;70:377–9.
46. Jenkins TPN. The burst abdominal wound: a mechanical approach. Br J Surg. 1976;63:873–6.
47. IJpma FF, Boddeus KM, de Haan HH, et al. Bilateral round ligament varicosities mimicking inguinal hernia during pregnancy. Hernia. 2009;13:85–8.
48. Lechner M, Fortelny R, Ofner D, et al. Suspected inguinal hernias in pregnancy—handle with care! Hernia. 2014;18:375–9.
49. Aabakke AJ, Krebs L, Ladelund S, et al. Incidence of incisional hernia after cesarean delivery: a register-based cohort study. PLoS One. 2014;9:e108829.
50. Mikkelsen T, Bay-Nielsen M, Kehlet H. Risk of femoral hernia after inguinal herniorrhaphy. Br J Surg. 2002;89:486–8.
51. Kuczkowski KM. Nonobstetric surgery during pregnancy: what are the risks of anesthesia? Obstet Gynecol Surv. 2004;59:52–6.
52. Hawkins JL, Koonin LM, Palmer SK, et al. Anesthesia related deaths during obstetric delivery in the United States, 1979–1990. Anesthesiology. 1997;86:277–84.
53. Kilpatrick CC, Monga M. Approach to the acute abdomen in pregnancy. Obstet Gynecol Clin N Am. 2007;34:389–402.

54. Oma E, Bisgaard T, Jorgensen LN, et al. Nationwide propensity-score matched study of mesh versus suture repair of primary ventral hernias in women with a subsequent pregnancy. World J Surg. 2019;43:1497–504.
55. Haskins IN, Rosen MJ, Prabhu AS, et al. Umbilical hernia repair in pregnant patients: review of the American College of Surgeons National Surgical Quality Improvement Program. Hernia. 2017;21:767–70.
56. Kwan J, Rooney PS, Chandrasekar CR. Pregnancy after abdominal wall mesh repair in desmoid fibromatosis. J Obstet Gynaecol. 2017;37:379–80.