Abdominal emergencies during pregnancy

J. Bouyou\textsuperscript{a,} S. Gaujoux\textsuperscript{a,b,} L. Marcellin\textsuperscript{b,c,e,} M. Leconte\textsuperscript{a,b,} F. Goffinet\textsuperscript{b,d,e,} C. Chapron\textsuperscript{b,c,} B. Dousset\textsuperscript{a,b,}\textsuperscript{*}

\textsuperscript{a} Service de chirurgie digestive, hépatobiliaire et endocrinienne, Hôpital Cochin, AP–HP, Paris, France
\textsuperscript{b} Faculté de médecine, Université Paris Descartes, Sorbonne Paris Cité, Paris, France
\textsuperscript{c} Département de gynécologie-obstétrique II et médecine de la reproduction, Hôpital Cochin-Port Royal, AP–HP, Paris, France
\textsuperscript{d} Maternité, Hôpital Cochin-Port Royal, Paris, France
\textsuperscript{e} DHU Risques et Grossesse, Université Paris Descartes, Paris, France

Available online 30 October 2015

Summary Abdominal emergencies during pregnancy (excluding obstetrical emergencies) occur in one out of 500–700 pregnancies and may involve gastrointestinal, gynecologic, urologic, vascular and traumatic etiologies; surgery is necessary in 0.2–2% of cases. Since these emergencies are relatively rare, patients should be referred to specialized centers where surgical, obstetrical and neonatal cares are available, particularly because surgical intervention increases the risk of premature labor. Clinical presentations may be atypical and misleading because of pregnancy-associated anatomical and physiologic alterations, which often result in diagnostic uncertainty and therapeutic delay with increased risks of maternal and infant morbidity. The most common abdominal emergencies are acute appendicitis (best treated by laparoscopic appendectomy), acute calculous cholecystitis (best treated by laparoscopic cholecystectomy from the first trimester through the early part of the third trimester) and intestinal obstruction (where medical treatment is the first-line approach, just as in the non-pregnant patient). Acute pancreatitis is rare, usually resulting from trans-ampullary passage of gallstones; it usually resolves with medical treatment but an elevated risk of recurrent episodes justifies laparoscopic cholecystectomy in the 2nd trimester and endoscopic sphincterotomy in the 3rd trimester. The aim of the present work is to review pregnancy-induced anatomical and physiological modifications, to describe the main abdominal emergencies during pregnancy, their specific features and their diagnostic and therapeutic management.

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 Abbreviation: ALP, after last period.

* Corresponding author at: AP–HP, Groupe Hospitalier Universitaire Ouest, CHU Cochin Broca Hôtel-Dieu, Service de chirurgie digestive, hépatobiliaire et endocrinienne, 27, rue du Faubourg-Saint-Jacques, 75014 Paris, France.

E-mail address: bertrand.dousset@cch.aphp.fr (B. Dousset).
Introduction

Abdomino-pelvic pain during pregnancy is a frequent reason for emergency consultation. Aside from the commonplace minor pains of pregnancy, multiple etiologies may lead to abdominal emergency in the pregnant woman. One must first consider typical obstetrical causes such as placental abruption, non-labor-related uterine rupture, subcapsular hematoma of the liver, hemoperitoneum due to <i>placenta percreta</i>, each of which has specific management requirements. Abdominal pain can also arise from gastrointestinal disease (appendicitis, cholecystitis, bowel obstruction, hepatic or splenic rupture), vascular pathology (splenic aneurysm, aortic aneurysmal dissection), gynecologic pathology (aseptic necrosis of a uterine fibroid, ovarian or tubal torsion), urologic pathology (nephrolithiasis with renal colic, pyelonephritis), or trauma. Non-obstetrical medico-surgical emergencies complicate one in 500–700 pregnancies [1–4]. Many of these pathologies require surgical intervention (0.2–2% of cases [5,6]), the most common being acute appendicitis [7], adnexal masses (asymptomatic or symptomatic) [8], and acute cholecystitis [9].

The anatomical particularities and physiologic modifications of pregnancy often lead to atypical or misleading clinical presentations. Since these emergencies are relatively rare, most specialists have very limited experience with them, which may result in diagnostic hesitation or therapeutic delay. Since two lives are at risk, both mother and infant, these patients should be managed in specialized centers where surgical management can be supplemented by specific obstetrical and/or neonatal management depending on the gestational stage. Complications that may arise are often due to delays in diagnosis and management.

The aim of this review is to describe in detail the most common medical and surgical emergencies that arise during pregnancy, along with particularities of their diagnostic and therapeutic management.

Specifics of the clinical exam, imaging, and laboratory work-up of the pregnant patient

Optimal management of women presenting with acute abdominal pain during pregnancy requires a close collaboration between surgeons, obstetricians and radiologists.

Clinical examination

The anatomic and physiologic changes of pregnancy modify both the symptoms and the physical examination of patients with abdominal diseases. The uterus cannot be felt transabdominally until it rises up out of the pelvis 12 weeks after the last period (ALP). As pregnancy progresses, the uterine fundus reaches the upper edge of pubis at the end of the 10th week ALP (2nd month) and becomes palpable at the end of the 12th week ALP when the fundus lies eight cm or three fingerbreadths above the symphysis pubis. At 18 weeks ALP, the fundus reaches the level of the umbilicus and at term, it lies 32 cm above the symphysis pubis (Table 1 and Fig. 1). The Fournié formula offers a simple calculation of uterine height throughout gestation. Between 16 and 32 weeks ALP, the range of measured suprapubic uterine height (in cm) is equal to the number of weeks ALP minus 4 to plus 1. After 32 weeks ALP, the uterine fundal height increases by 0.5 cm per week or 2 cm per month (Table 1).

The position of the gravid uterus

In the 1st trimester of pregnancy, the uterus remains within the pelvis, but it becomes intra-abdominal thereafter as the uterus enlarges [10]. At term, the uterine position relative to surrounding anatomy is:

- anterior: adjacent to the anterior abdominal wall although the greater omentum and small bowel loops are occasionally interposed anteriorly, particularly when abdominal adhesions were present prior to pregnancy. As the uterus enlarges, the thickness of the abdominal wall

Table 1 Normal values of uterine height as a function of gestational age.

<table>
<thead>
<tr>
<th>Months of pregnancy</th>
<th>Weeks ALP</th>
<th>Mean uterine height (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>20</td>
<td>16 ± 1</td>
</tr>
<tr>
<td>4,5</td>
<td>22</td>
<td>At the umbilicus ± 1</td>
</tr>
<tr>
<td>5</td>
<td>24</td>
<td>20 ± 1.5</td>
</tr>
<tr>
<td>6</td>
<td>28</td>
<td>24 ± 1.5</td>
</tr>
<tr>
<td>7</td>
<td>33</td>
<td>28 ± 2</td>
</tr>
<tr>
<td>8</td>
<td>37</td>
<td>30 ± 2</td>
</tr>
<tr>
<td>9</td>
<td>41</td>
<td>32 ± 2</td>
</tr>
</tbody>
</table>

ALP: after last period.

Figure 1. Uterine height as a function of gestational age (J. Laman).
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Temperature
Elevated progesterone levels during early pregnancy result in a temperature exceeding 37 throughout the 1st trimester. This returns to normal during the last two trimesters with a tendency to hypothermia during the last few weeks of pregnancy [17].

Cardiovascular and hemodynamic modifications
The essential characteristic of cardiovascular adaptations of pregnancy is the early onset of arterial vasodilatation, which may account for increased cardiac output and, in turn, leads to activation of the renin-angiotensin-aldosterone axis with a resultant increase in "cardiac work" (Fig. 2). At the same time, sodium and water retention due to the combined effect of estrogens and aldosterone secretion result in hypervolemia. Plasma volume progressively increases throughout pregnancy up to the 28th week ALP after which it stabilizes. This plasma volume augmentation correlates with the number and size of the fetus(es), and amounts to a 30–40% increase, or >1000 mL (600–1900 mL) by the third trimester. Cardiac output also increases by 30–50% due to a 15% increase in cardiac rate (15% or 15–20 beats/minute in the third trimester) and to a 30% increase in systolic ejection volume. The glomerular filtration rate (GFR) increases by 15% in early pregnancy and by 50–70% by late pregnancy, due to increased renal plasma flow [18]. Arterial pressure is a function of cardiac output and peripheral resistance. Despite an increase in cardiac output, blood pressure decreases by 20–30% due to decreased peripheral resistance from the 7th through the 24–28th weeks ALP. Thereafter, arteriovenous shunts created by the fetoplacental circulation plus the vasomotor effects of placental hormones lead to a progressive increase in peripheral resistance and a return of arterial blood pressure to normal pre-pregnancy levels at term. The venous pressure in the upper body remains unchanged, but the venous pressure of the lower extremities increases, especially towards the end of pregnancy, as dextrorotation of the enlarging uterus compresses the IVC. Increased IVC pressure impairs venous return from the lower extremities and favors the development of edema and venous varicosities of the legs and hemorrhoids.

Respiratory modification
There is an increase of both pulmonary blood flow and oxygen uptake. The increased oxygen needs of the fetus and placenta amount to 20–30% and are manifested clinically by tachypnea in the range of 16 breaths per minute. At least 50% of pregnant women have clinical dyspnea at term [19].

Digestive, hepatic and urinary modifications
Slowing of gastric emptying and decreased tone of the lower esophageal sphincter result in gastro-esophageal reflux with symptoms of heartburn by the end of the first trimester, which progressively worsens throughout pregnancy. This affects 80% of pregnant women and results in frequent episodes of regurgitation. Acid secretion decreases by 40%; the increase in gastric pH in the first two trimesters may account for decreased gastric tone and motility. This may be a partial explanation of pregnancy-associated nausea. Small intestinal and colonic transit time is increased with an associated increase in colonic water absorption resulting in a tendency to constipation. High progesterone levels lead to decreased gallbladder tone, poor emptying, and biliary
stasis. At the same time, higher estrogen levels result in an increased concentration of cholesterol and lithogenicity of bile. The combined effects of gallbladder stasis and lithogenic bile result in an increased risk of cholecystolithiasis during pregnancy. During the third trimester, although liver volume is unchanged, the liver is not palpable as it is pushed superiorly, posteriorly and to the right by the enlarging uterus.

Finally, uterine compression of the ureters at the brim of the pelvis causes pyelo-calyceal enlargement beginning at the 6th week ALP; this is more prominent on the right side due to dextrorotation of the uterus. It results in an increased tendency to urinary stasis and infection [18].

Uterine contractions
Up to a dozen intermittent, non-painful contractions per day should be considered physiologic and normal throughout the 3rd trimester. After 37 weeks ALP, these contractions become more frequent, sustained, and intense; they are associated with progressive effacement of the lower uterine segment in preparation for labor and delivery. Severe contractions before 37 weeks ALP should be considered as warning signs of the onset of premature labor and delivery.

Immune system modifications
In a simplified way of thinking, the fetus can be considered to be a sort of physiologic allograft since it expresses paternal antigens. During pregnancy, the maternal immune system develops transient immune tolerance to fetal antigens while maintaining its ability to protect against infectious pathogens. Nonetheless, this temporary immunodepression makes the mother more susceptible to infections [17].

Particularities of laboratory findings
The various physiologic adaptations of pregnancy described above result in alterations in normal values of laboratory examinations (Table 2).

Hematology
Red blood cell (RBC) mass increases beginning after the 12th week ALP. RBC volume increases by 20% under the influence of hormonal stimulation of erythropoietin. With iron supplementation, this augmentation may increase from 250 mL to 450 mL. However, plasma volume increases more than RBC volume resulting in relative hemodilution and a fall in hemoglobin concentration, the so-called “physiologic anemia of pregnancy”. The lower limits of normal for hemoglobin concentration and hematocrit during pregnancy range from 11 g/dL with a hematocrit of 32% in the 1st and 3rd trimesters, and slightly lower in the 2nd trimester at 10.5 g/dL. The platelet count remains stable, but gestational thrombocytopenia occurs in 4–8% of women as pregnancy approaches term; this should not be mistaken for a manifestation of the HELLP syndrome (hemolysis, elevated liver enzymes, low platelet count), which complicates 10–15% of cases of preeclampsia. Physiologic
Table 2  Normal laboratory values at each trimester of pregnancy.

<table>
<thead>
<tr>
<th>Table 2  Normal laboratory values at each trimester of pregnancy.</th>
<th>1st trimester</th>
<th>2nd trimester</th>
<th>3rd trimester</th>
</tr>
</thead>
<tbody>
<tr>
<td>Complete blood count</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hemoglobin (g/dL)</td>
<td>11.7–13.7</td>
<td>9.7–11.5</td>
<td>9.8–12.3</td>
</tr>
<tr>
<td>Hematocrit (%)</td>
<td>36</td>
<td>33</td>
<td>34</td>
</tr>
<tr>
<td>Leucocytes (per mm²)</td>
<td>3150–15,300</td>
<td>6300–16,100</td>
<td>5000–16,600</td>
</tr>
<tr>
<td>Platelet count (per mm²)</td>
<td>No change</td>
<td>No change</td>
<td>No change</td>
</tr>
<tr>
<td>Liver function tests</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ASAT/ALAT</td>
<td>No change</td>
<td>No change</td>
<td>No change</td>
</tr>
<tr>
<td>Bilirubin direct (µmol/L)</td>
<td>No change</td>
<td>No change</td>
<td>No change</td>
</tr>
<tr>
<td>Bilirubin total (µmol/L)</td>
<td>No change</td>
<td>No change</td>
<td>No change</td>
</tr>
<tr>
<td>Alkaline phosphatase (IU/L)</td>
<td>No change</td>
<td>2–15 × normal</td>
<td>2–15 × normal</td>
</tr>
<tr>
<td>GGT (IU/L)</td>
<td>No change</td>
<td>No change</td>
<td>No change</td>
</tr>
<tr>
<td>Electrolytes and blood chemistries</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Na+ (mmol/L)</td>
<td>140 ± 5</td>
<td>Stable</td>
<td>Stable</td>
</tr>
<tr>
<td>K+ (mmol/L)</td>
<td>3.5–4.5</td>
<td>Stable</td>
<td>Stable</td>
</tr>
<tr>
<td>Creatinine (µmol/L)</td>
<td>Decreased</td>
<td>Decreased</td>
<td>Decreased</td>
</tr>
<tr>
<td>Urea (g/L)</td>
<td>Decreased</td>
<td>Decreased</td>
<td>Decreased</td>
</tr>
<tr>
<td>Lipase (IU/L)</td>
<td>Decreased</td>
<td>Stable</td>
<td>Stable</td>
</tr>
<tr>
<td>Amylase (IU/L)</td>
<td>No change</td>
<td>No change</td>
<td>No change</td>
</tr>
<tr>
<td>Total protein (%)</td>
<td>No change</td>
<td>No change</td>
<td>No change</td>
</tr>
<tr>
<td>Prothrombin time (INR)</td>
<td>No change</td>
<td>No change</td>
<td>No change</td>
</tr>
<tr>
<td>Other laboratory tests</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CRP (mg/L)</td>
<td>No change</td>
<td>No change</td>
<td>No change</td>
</tr>
<tr>
<td>Sedimentation rate (mm/h)</td>
<td>Very high</td>
<td>Very high</td>
<td>Very high</td>
</tr>
</tbody>
</table>

Leukocytosis may rise as high as 16,000 WBC/mm³ during the 2nd trimester due to an increase in polymorphonuclear leukocytes.

Hepatobiliary
Physiologic and laboratory alterations towards the end of pregnancy result in increased levels of alkaline phosphatase (2–15 times normal due to placental and osseous production of iso-enzymes) and fibrinogen and a hemodilutional decrease in levels of albumin, bilirubin and γGT. An increase of liver transaminases to more than twice normal should be considered pathologic [20].

Hemostasis
Most coagulation factors increase during pregnancy while coagulation inhibitors and fibrinolytic capacity decrease. Alterations of the hemostatic mechanism result in a relatively hypercoagulable state, which increases throughout pregnancy [21]. The physiologic increase in fibrinogen levels during pregnancy should not be considered to be a marker for inflammation in this context [22,23].

Renal
GFR and creatinine clearance both increase during pregnancy, along with a hemodilutional decrease in serum creatinine, urea, iodine, calcium, and uric acid. Interpretation of urinary dipstick findings remains unchanged [18].

Particularities of imaging for abdominal emergencies
Ultrasound is the first choice for abdominal imaging in pregnancy because it is rapid, widely available, and because it avoids radiation exposure. It is an effective diagnostic tool for gynecologic, gastrointestinal, urinary, and hepatobiliary pathologies. It is also effective in detecting obstetrical pathologies and assessing fetal condition. Its effectiveness is somewhat limited for evaluation of the intestine, pancreas, ureters and mesenteric vasculature because its visibility is limited by the interposed uterus and by the presence of intestinal air.

Magnetic resonance imaging (MRI) has been shown to be effective in evaluating specific etiologies of acute abdominal pain during pregnancy [24]. Because it avoids exposure to ionizing radiation, MRI is the preferred second-line diagnostic modality when ultrasound is inconclusive. At the present time, no scientific evidence has established that the use of MRI during pregnancy constitutes a risk for the fetus. The American College of Radiology recommends that MRI be used instead of CT during pregnancy. Gadolinium, administered as a contrast agent, crosses the placental barrier into the fetal circulation, is filtered by the fetal kidneys and excreted into the amniotic fluid. It should be used only sparingly since the risks of secondary fetal effects such as nephrogenic systemic fibrosis have not been clearly established [25] (CRAT – http://www.lecrat.org/ – Reference Center for Teratogenic Agents). The use of Gadolinium enhancement is currently recommended for certain specific obstetrical situations, particularly for cases of invasive placentation (placenta percreta), in order to define the degree of extension and anatomic relations of the placenta.

While the dosage of X-irradiation from current CT techniques is small, X-ray exposure should be avoided during pregnancy, particularly during the 1st trimester, because of possible teratogenic effects. The benefits of CT must be weighed against the risks of radiation exposure and clearly explained to the parents. When a patient with a previously unrecognized pregnancy undergoes CT scan, even in early pregnancy, this is not a sufficient indication for termination of pregnancy. However, when CT must be performed in a patient with known pregnancy, the
number of cuts and images should be strictly limited and, if possible, the uterus should be shielded with a lead apron.

Studies have shown that cumulative exposure of up to 50 mGy of ionizing radiation (the equivalent of 5 abdominal plain X-rays or 1–2 abdominal CT scans) result in no significant increase in teratogenic risk. CT of the maternal pelvis may result in fetal X-ray exposure of between 25 and 80 Gy, depending on the parameters of the CT scanner. Several studies [25,26] have shown that teratogenic effects of CT radiation are very unlikely for doses up to 100 mGy. The teratogenic effects of ionizing radiation (microcephaly, micro-ophthalmia, mental retardation, growth retardation, cataracts, behavioral problems) become evident only after higher doses of radiation and, in particular, for radiation delivered between the 2nd and 20th week ALP.

Other studies have shown that in utero radiation exposure is associated with an increased risk of childhood cancer; this risk may double (2/1000) when radiation exposure exceeds 50 mGy. According to the Oxford Survey of Childhood Cancers, this increased risk is most marked when radiation exposure occurs during the 1st trimester rather than the 2nd or 3rd trimester, with relative risks of 3.19, 1.29, and 1.30, respectively [26]. Intravenous iodinated contrast agents have not been shown to increase teratogenic risk in either animals or humans. However, animal studies suggest that exposed newborns should be tested for neonatal hypothyroidism [27]. In sum, the low risks associated with CT scan during the 2nd and 3rd trimesters suggest that CT scan with IV contrast can be performed in pregnant women, if necessary, to avoid delay in diagnosis and management of abdominal emergencies.

**Diagnostic work-up for abdominal pain during pregnancy**

Abdominal pain during pregnancy is a common reason for consultation, albeit with varying degrees of urgency. The diagnostic hypotheses should be prioritized, taking into account the patient’s history and the term of pregnancy. Gynecological and obstetrical conditions that may potentially cause abdominal pain must be considered at the outset and rapidly diagnosed to allow prompt appropriate care, especially since two lives, maternal and fetal, are at risk.

Several obstetrical pathologies may present with acute abdominal pain. These often require urgent cesarean section to preserve maternal and fetal life; no diagnostic studies should delay this urgent decision:

- retro-placental hematoma preferentially occurs in the setting of preeclampsia. This typically presents as constant intense blunt abdominal pain, with a hypertonic “hard as wood” uterus and possibly with metrorrhagia;
- uterine rupture can occur de novo, or more commonly with a past history of uterine surgical scar. Abdominal pain may be associated with vaginal bleeding, deformation of the abdomen, or hemoperitoneum;
- subcapsular hematoma of the liver is a specific complication of preeclampsia and the HELLP syndrome;
- hemoperitoneum may be associated with severe abdominal pain in cases of placenta percreta, vascular malformation, or hemorrhage from an endometriosis lesion;
- utero-adnexal pathologies such as ectopic pregnancy, ruptured corpus luteum cyst, adnexal torsion or subserosal fibroid with pedicular torsion are all possible causes of acute abdomino-pelvic pain in pregnant women that may require urgent surgical management.

Any physician taking care of a pregnant woman must first consider these gynecological and obstetrical etiologies of acute abdominal pain. These causes apart, the main causes of abdominal emergency during pregnancy are acute appendicitis, acute cholecystitis, bowel obstruction, acute pancreatitis, abdominal trauma and renal colic.

**Principles and particular features of surgical management**

When a surgical intervention is indicated, the question of laparoscopic versus laparotomy approach must be discussed in terms of its feasibility during pregnancy. Laparoscopic indications in the treatment of abdominal emergencies in the pregnant patient are no different from those for a non-pregnant a patient [28–30].

Laparotomy has long been the preferred surgical approach during pregnancy. However, the development of laparoscopy has led to increasingly widespread use. Laparoscopy has multiple advantages including: reduced postoperative pain with decreased consumption of analgesics, particularly morphine; reduced risk of postoperative maternal hypoventilation; more rapid mobilization and ambulation with a resultant reduction in thromboembolic risk, parietal complications and duration of hospitalization [31]. Specific precautions are necessary to guard against the inherent risks of this approach: uterine laceration, intra-amniotic insufflation, CO2 fetotoxicity due to passive transplacental diffusion of insufflation gas, and diminution of utero-placental blood flow due to high intraperitoneal pressure [32–34].

No studies have shown the superiority of open-laparoscopy versus Verres needle-insufflation. Guidelines issued by the CNGOF in 2010 recommend against Verres needle-insufflation needle beyond 14 weeks ALP; they encourage open-laparoscopy with incisional placement determined by the term of pregnancy, uterine volume and operative indications. Beyond 24 weeks ALP, the incision should be placed supra-umbilical. Insufflation pressure should not exceed 12 mm Hg and changes of patient position should be gradual with only moderate Trendelenburg. All instrumental contact with the uterus during surgery should be avoided since this can cause serosal bleeding or provoke uterine contractions [7,35].

From an obstetrical viewpoint, spontaneous or induced pre-term delivery should be prevented because of poor fetal tolerance, but such complications should be anticipated by pre-intervention transfer to surgical unit where a suitable level of obstetrical and neonatal care is available. Antenatal steroid administration to accelerate development of fetal pulmonary surfactant (2 intramuscular injections of 12 mg of betamethasone at 24 hours interval) should be considered on a case-by-case basis when there is risk of pre-term labor or induced pre-term birth, if the pregnancy has reached a term of fetal viability (~24 weeks ALP) without pulmonary maturity (34 weeks ALP). There is no indication for routine administration of tocolytic agents unless there are symptoms of threatened premature delivery [36]. However, if repeated uterine contractions develop before 34 weeks ALP, particularly if there are signs of cervical ripening, tocolysis should be performed using calcium channel
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Incidence, diagnostic particularities and specific management of major abdominal emergencies during pregnancy

Acute appendicitis

Acute appendicitis is the most common surgical emergency during pregnancy with an estimated incidence of 0.5–2 per 1000 pregnant women, i.e., 25% of all non-obstetrical surgical emergencies [7] (Table 3). It occurs more frequently in the 2nd trimester of pregnancy [9,40,41]; pregnancy does not modify the overall incidence of appendicitis.

Diagnostic difficulties may arise, particularly during the 2nd and 3rd trimesters, due to misleading or atypical symptomatology associated with changes in the appendiceal position as it is displaced progressively upward by the enlarging uterus. Bann et al. [42] described progressive ascent of the appendix from the third month onward, reaching the level of the iliac crest by the end of the 6th month, and return to its usual position by the tenth day postpartum [43]. The most suggestive symptom is right lower quadrant abdominal pain, which is found in 80% of cases [43]. But, tenderness can also be localized in the right flank, the right lumbar fossa and sometimes even in the right upper quadrant. Rebound tenderness (55–75% of cases) and muscular guarding (50–65%) are classical signs; they can be partially masked, but should always be sought. A positive psoas sign is rare. Anorexia, nausea and vomiting are present in 87% of cases [44], but these nonspecific symptoms are commonplace early in pregnancy. Fever is present in only 50% of cases. Leukocytosis is already physiologically present in pregnant women and has low sensitivity and specificity, while the CRP level may be normal.

Ultrasound is the key diagnostic tool, especially in the 1st trimester; technical difficulties decrease its diagnostic value in the third trimester. The diagnostic accuracy of ultrasound is highly variable and depends on the experience of the operator; sensitivity and specificity range from 50 to 100% and from 33 to 92%, respectively [24]. If ultrasound fails to diagnose appendicitis because the appendix cannot be clearly identified (whether normal or not), MRI is then the second-choice diagnostic modality with a sensitivity of 100% and a specificity of 94% [45]. If MRI is not available or is impracticable, then CT becomes the alternative diagnostic modality. The risk of missing the diagnosis of appendicitis in pregnancy outweighs the low but finite risks of irradiation. The diagnostic accuracy of CT during pregnancy is similar to that of the general population with a sensitivity and specificity of 92% and 99%, respectively.

Diagnostic delay is associated with a higher risk of complications such as perforation, which is associated with a 20–35% rate of perforated appendicitis. In a series of 84 patients, Tamir et al. reported a 43% incidence of appendiceal perforation when surgery was delayed for more than 24 hours, whereas no cases of perforation was described when surgical management took place within 24 hours following admission [46].

Among other consequences, premature labor is very common (83% rate of premature uterine contractions when localized peritonitis was present) with a pre-term birth rate exceeding 50% in the 3rd trimester.

The treatment of acute appendicitis in pregnant women is surgical appendectomy; the management strategy must be adapted to several factors such as gestational age, severity of appendicitis, body mass index, history of previous abdominal surgery, ability and preferences of the surgeon. Laporoscopic appendectomy, which has become standard first-line treatment during pregnancy is associated with a low complication rate, no matter what the gestational stage [47]. If open laparotomy is chosen, a classical McBurney incision can be used during the 1st trimester. In the 2nd and 3rd trimester, the incision must be placed higher on the right, while some surgeons feel that an upper midline incision allows better access to the ceco-appendicular region [48]. If generalized peritonitis is present, a longer midline incision extending above and below the umbilicus allows broad access for easy exploration and adequate peritoneal lavage and toilet of the entire peritoneal cavity.

Acute cholecystitis

Gallbladder disease, particularly acute cholecystitis, is the second leading cause of non-obstetrical abdominal emergency after appendicitis. Its incidence is one per 1600–10,000 pregnancies. Cholelithiasis is the etiologic
cause in 90% of cholecystitis. Cholelithiasis is present in 3.5 to 10% of pregnant women [49, 50]. Symptoms are almost identical to those in non-pregnant patients and include nausea and vomiting, dyspepsia, fatty food intolerance, and colicky right upper quadrant or epigastric pain that may radiate to the back. However, Murphy’s sign is less relevant in advanced-stage pregnancy. The differential diagnosis includes numerous conditions and one must consider obstetric pathology such as gestational acute fatty liver, either de novo or due to HELLP syndrome complicating preeclampsia. The differential diagnosis also includes acute appendicitis, preeclampsia, acute hepatitis, acute pancreatitis, peptic ulcer, acute right-sided pyelonephritis, or right basilar pneumonia. When interpreting laboratory findings, it is important to remember that an elevated alkaline phosphatase level is physiological during pregnancy.

Ultrasound is the diagnostic modality of choice because it is non-invasive, non-irradiating, readily available, and has 95–98% sensitivity for detection of gallstones [51]. Conventional criteria for ultrasound diagnosis of acute cholecystitis include a sonographic Murphy’s sign, presence of cholecystolithiasis, increased gallbladder size (> 4 cm), gallbladder sludge, thickening of the gallbladder wall (> 4 mm), and pericholecystic fluid. Dilatation of the intra- or extrahepatic bile ducts suggests the diagnosis of cholecystocholedocholithiasis.

Surgery is the first-line of treatment. It reduces the use of medications and avoids recurrent bouts of cholecystitis that occur in 44–92% of medically treated patients depending on the pregnancy stage and length of time to term. Surgery reduces the length of stay and avoids the onset of serious complications such as sepsis or perforation with peritonitis. Furthermore, symptomatic cholelithiasis is associated with a 10% risk of acute gallstone pancreatitis and a 10–20% risk of miscarriage [52]. Non-surgical management is also associated with a higher incidence of spontaneous abortion, threatened abortion, and premature birth when compared to patients who underwent cholecystectomy [53]. Laparoscopy is the recommended approach up to the beginning of the 3rd trimester. Maternal mortality with laparoscopic cholecystectomy is not increased by the pregnancy [54].

### Bowel obstruction

Bowel obstruction is the third most common cause of non-obstetrical abdominal emergency during pregnancy with a frequency of 1 in 1500–16,000 pregnancies. Adhesive bands account for 60–70% of obstructions (Fig. 3); this is particularly likely when past history includes previous abdominal surgery or peritonitis. Volvulus is found in about 25% of cases [55], while it accounts for < 1% of bowel obstructions in non-pregnant patients [56]. The risk of cecal volvulus increases as pregnancy progresses, particularly during the rapid increase in uterine size between 16 and 20 weeks ALP when the uterus becomes intra-abdominal, and between 32 and 36 weeks when the fetus descends into the pelvis, and also postpartum when the uterus rapidly shrinks in size. Small intestinal volvulus accounts for 9% of bowel obstructions during pregnancy [57]. Other rare causes including intussusception, strangulated hernia, cancer and diverticulitis account for 5% of bowel obstructions during pregnancy [58]. In a relatively old series reported by Perdue et al. in 1992 [55], a high maternal mortality of 6% with a 26% rate of fetal mortality were noted, with a 23% rate of intestinal resection. Current rates of morbidity and mortality are much lower due to improved diagnostic and therapeutic performance. Symptoms of bowel obstruction are the same as in non-pregnant patients: abdominal pain with spasmodic cramping, distention, nausea, vomiting, and arrested intestinal transit of stool and gas. However, the symptoms can be attenuated or atypical; one must be vigilant to rule out bowel obstruction when faced with a pregnant patient with intractable vomiting, especially after the 1st trimester.

Dilated small bowel loops with dynamic air-fluid levels are present on plain abdominal X-ray in 82% of patients with an obstructive syndrome [55]. Abdominal X-ray can make the

<table>
<thead>
<tr>
<th>Pathology</th>
<th>Incidence</th>
<th>Maternal mortality</th>
<th>Fetal risk (miscarriage, FDIU*, abortion)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acute appendicitis</td>
<td>1/500–2000</td>
<td>&lt; 1%</td>
<td>&lt; 1.5% if non-perforated</td>
</tr>
<tr>
<td>Acute cholecystitis</td>
<td>1/1600–10,000</td>
<td>Same as for non-pregnant patients</td>
<td>1–2% if perforated</td>
</tr>
<tr>
<td>Bowel obstruction</td>
<td>1/1500–16,000</td>
<td>&lt; 5%</td>
<td>&lt; 20%</td>
</tr>
<tr>
<td>Acute pancreatitis</td>
<td>1/1000–3000</td>
<td>Same as for non-pregnant patients</td>
<td>&lt; 5%</td>
</tr>
<tr>
<td>Abdominal trauma</td>
<td>6–7%</td>
<td>Varies with severity of trauma</td>
<td>Varies with severity of trauma</td>
</tr>
</tbody>
</table>

* FDIU: fetal death in utero.

Note: The table provides incidence rates and maternal mortality percentages for various abdominal emergencies during pregnancy. The fetal risk includes complications like miscarriage and abortion. The table also highlights the increased risk of fetal death in utero associated with bowel obstruction. The incidence rates are based on various studies, with acute appendicitis being the commonest, followed by bowel obstruction. The maternal mortality risk is relatively low, but the fetal risk is significant, especially with perforation. The table underscores the importance of early diagnosis and intervention to prevent complications.
Abdominal trauma

Abdominal trauma occurs during pregnancy with a frequency of 6–7%, consisting mainly of motor vehicle accidents, physical assault (often domestic violence) and falls. Trauma is the most common cause of non-obstetrical maternal death, but only 0.3% of injuries require surgical intervention [64,65].

The clinical presentation of abdominal trauma during pregnancy varies widely. The medical history should clearly elicit the traumatic mechanism and distinguish direct from indirect impact. Their consequences must not be underestimated, especially in the late stages of pregnancy. Work-up should include a complete physical examination of the mother, specifically searching for visceral, musculoskeletal, and central nervous system trauma. In addition to maternal vital signs, the fetal heart rate should be monitored and an ultrasound assessment of fetal viability performed.

A Kleihauer test should be performed to detect the presence of fetal red blood cells in the maternal circulation due to fetal-maternal hemorrhage. The patient may require a 24-hour surveillance hospitalization. In some cases, trivial maternal damage may result in serious consequences for the fetus. On the other hand, reassurance is warranted if initial assessment shows no significant abnormality in the mother or fetus.

In blunt abdominal trauma, splenic rupture is the most common source of intraperitoneal bleeding. The increased size of the abdominal cavity with gradual stretching seems to decrease peritoneal bleeding sensation. Signs of peritoneal irritation may therefore be absent despite the existence of an abdominal injury. Uterine rupture is rare before three months of gestation because the uterus is only slightly enlarged and still protected within the bony pelvis; it occurs in <1% of traffic accidents with violent high kinetic energy transfer [66]. When uterine rupture occurs in this context, fetal prognosis is extremely poor and maternal risk is directly related to the degree of internal bleeding, which can be catastrophic and fatal. Caesarean section for maternal salvage is indicated and carries a high risk of hysterectomy. Placental abruption is very common. It can occur with even minor injuries, and may sometimes only become apparent after 24 to 48 hours. The difference in structure between the relatively rigid placenta and the more malleable uterus causes separation of the interface by a shearing effect. Placental abruption is found in 2–4% of minor injuries and 20–50% of major trauma. It results in a 20–35% fetal mortality but only a 1% maternal mortality [66]. In this context, laparoscopy is seldom indicated.

Trauma in pregnant women can be classified into four groups for whom specific management is adapted:

- group 1 consists of patients in early pregnancy, or who are unaware of pregnancy. It is essential to perform a pregnancy test in all women of childbearing age who have suffered significant trauma in order to adapt the work-up (particularly imaging) and management;

- group 2 consists of patients at <24 weeks gestation ALP, in whom the fetus is not yet viable, but is still well protected by the pelvis and has suffered little direct damage. Management is focused on the mother and medical termination of pregnancy may be indicated if the maternal prognosis depends on it;

- group 3 consists of patients whose pregnancy is ≥24 weeks, in whom a viable fetus is very vulnerable to injury because of its size and extrapelvic position. Close and constant monitoring of fetal viability is necessary.

diagnosis of cecal volvulus with a sensitivity of 95%. If bowel obstruction is still suspected despite the absence of typical findings on plain X-ray, contrast-enhanced imaging (abdominal X-ray after oral gastrografin or CT with IV contrast) may be necessary. The potential risks of fetal irradiation are largely offset by potential risks of maternal and fetal morbidity and mortality. For cecal volvulus without signs of grave complication, colonoscopy may be useful, but the rate of colonoscopic reduction of cecal volvulus is far lower than for sigmoid volvulus. It should not be allowed to delay surgical treatment. The decision tree for therapeutic management is the same as for non-pregnant patients. Medical treatment (NPO, nasogastric suction, fluid and electrolyte repletion) should be the initial step unless there are clinical, laboratory or imaging signs of clinical gravity. Failure of medical treatment or signs of gravity such as fever, tachycardia, marked leukocytosis combined with severe abdominal pain are justification for prompt surgical intervention. A midline laparotomy is recommended with its height adapted to uterine size [55,56].

Acute pancreatitis

The incidence of acute pancreatitis during pregnancy is approximately 0.3–1 per 1000 pregnant women. In the general population, 80% of acute pancreatitis is due either to gallstones or to alcoholic pancreatic toxicity (in roughly equal proportions); during pregnancy, cholelithiasis is by far the most common etiology, accounting for 67–100% of cases [59]. Hypertriglyceridemia is responsible for 4–6% of acute pancreatitis during pregnancy. Acute pancreatitis occurs more frequently in the 3rd trimester. The diagnosis of acute pancreatitis in pregnancy is also difficult to make because the typical symptoms including sudden severe epigastric pain penetrating to the back, with nausea and post-prandial vomiting, ± fever can also evoke a serious obstetric complication such as retro-placental hematoma, or a complication of preeclampsia or HELLP syndrome that warrants an emergency caesarean section. Elevation of lipase level to thrice normal standard supports the diagnosis. Ultrasound is the first-line imaging study and should be complemented by MRI to assess severity according to the usual criteria; antibiotic prophylaxis must be considered for severe forms (beyond Balthazar stage D). Management is the same as for non-pregnant patients (NPO), with IV fluids, electrolyte, and vitamin replacement in an intensive care unit, with monitoring of the fetal heart rate.

Most patients respond to medical treatment within a few days and cautious feeding can be allowed by the fourth day. Management decisions following resolution of an acute episode are more delicate and depend on the stage of pregnancy, particularly because the recurrence rate of acute gallstone pancreatitis in pregnant women is 70% (90% during the initial hospitalization) versus 20–30% for the general population [60]. Surgery should be avoided during the 1st trimester, while laparoscopic cholecystectomy should be considered in the 2nd trimester. In the 3rd trimester, endoscopic retrograde cholangiopancreatography (ERCP) with sphincterotomy is a safe and effective alternative that allows deferral of cholecystectomy until after childbirth [61]. Indeed, the rate of premature birth is almost zero when cholecystectomy is performed in the 2nd trimester, but approaches 40% in the 3rd trimester. In the 1970s, the fetal mortality rate was 37%; nowadays thanks to earlier diagnosis and better neonatal care, perinatal mortality is less than 5% [62,63].
An emergency caesarean section may be indicated if fetal viability is threatened, precipitating the delivery of a premature newborn with consequences determined by gestational age and birth weight. However, exploratory laparotomy for suspected maternal hemoperitoneum does not always pre-suppose fetal extraction. For a fetus that has reached the threshold of viability, survival after emergency caesarean section for maternal trauma depends on gestational age and birth weight. More than half (60%) of neonatal deaths are due to a delay in the diagnosis of fetal distress leading to delay in caesarean section [67];

• group 4 consists of the rare cases of a mother in intractable hemorrhagic shock or cardiac arrest resistant to any treatment. Immediate “post-mortem” fetal extraction can be attempted in individual cases but neonatal survival depends on maintaining the fetal-placental circulation (fetal distress is betrayed by abnormalities of fetal heart rate in this context), the delay interval until extraction, and the availability of neonatal care at the place of birth. A 70% neonatal survival rate is noted when birth occurs within five minutes after the mother’s death, but this decreases to 3% after 20 minutes delay. In all cases, fetal extraction allows improved fetal prognosis after maternal circulatory arrest, whatever the gestational age [68].

Renal colic

Urolithiasis is a common disease; the incidence in pregnant women ranges from 0.026 to 0.5% depending on the study [69]. Diagnosis is based on clinical history, physical examination, laboratory testing, urinalysis and renal ultrasound. Standard analgesic treatment combining Tier 1 analgesics (paracetamol) and antispasmodics provides pain relief in 84% of cases. Non-steroidal anti-inflammatory drugs should be avoided and are contraindicated beyond 24 weeks ALP. The addition of short-term corticosteroid therapy when renal colic is resistant to standard therapy has been effective in 71% of patients and often permits postponement of surgery. Renal drainage by the introduction of a double-J endoureteral catheter/stent requires ongoing ultrasound and bacteriological surveillance throughout pregnancy. Extracorporeal lithotripsy and percutaneous nephrolithotomy are contraindicated during pregnancy [70,71].

Conclusion

Abdominal pain is a common cause of consultation during pregnancy. It is often the sign of anxiety-provoking but minor pregnancy-specific pathologies. But, it should not be underestimated and requires assessment to rule out gyneco-obstetrical causes. Abdominal pain due to gastrointestinal or urological causes may present with atypical or attenuated clinical symptoms; morphological assessment and imaging must be performed promptly to rule out causes that might require surgical intervention. If emergency surgery is indicated, it should be performed in a specialized center without delay; laparoscopy is usually an effective approach. The risk of spontaneous or induced premature delivery should be anticipated as much as possible with the implementation of a management strategy to reduce antenatal complications. It is crucial to fully inform parents of management choices.

Disclosure of interest

The authors declare that they have no competing interest.

References

Abdominal emergencies during pregnancy


