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Review

Non-obstetrical acute abdomen during pregnancy

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Abstract

Acute abdomen in pregnancy remains one of the most challenging diagnostic and therapeutic dilemmas today. The incidence of acute abdomen during pregnancy is 1 in 500–635 pregnancies. Despite advancements in medical technology, preoperative diagnosis of acute abdominal conditions is still inaccurate. Laboratory parameters are not specific and often altered as a physiologic consequence of pregnancy. Use of laparoscopic procedures as diagnostic tools makes diagnosis of such conditions earlier, more accurate, and safer. Appendicitis is the most common cause of the acute abdomen during pregnancy, occurring with a usual frequency of 1 in 500–2000 pregnancies, which amounts to 25% of operative indications for non-obstetric surgery during pregnancy. Surgical treatment is indicated in most cases, as in nonpregnant women. Laparoscopic procedures in the treatment of acute abdomen in pregnancy proved safe and accurate, and in selected groups of patients are becoming the procedures of choice with a perspective for the widening of such indications with more frequent use and subsequent optimal results. Despite these advances, laparotomy still remains the procedure of choice in complicated and uncertain cases.

Keywords: Acute abdomen; Pregnancy; Appendicitis; Cholecystitis; Pancreatitis; Bowel obstruction; Abdominal trauma

Contents

1. Introduction

The term ‘acute abdomen’ designates symptoms and signs of intraperitoneal disease that is usually best treated by surgical operation. The incidence of acute abdomen during pregnancy is 1 in 500–635 pregnancies [1,2]. Leading problems in the diagnosis of acute abdomen during pregnancy are:

(a) Expanding uterus, which dislocates other intra-abdominal organs and thus makes physical examination very difficult,
(b) high prevalence of nausea, vomiting, and abdominal pain in the normal obstetric population, and

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(c) general reluctance to operate unnecessarily on a gravid patient.

Therefore, close cooperation between surgeon and obstetrician is obligatory. The most common cause of the acute abdomen in pregnancy is acute appendicitis, but almost all causes of acute abdomen can manifest during pregnancy. The objective of this review is to give an overview of the most common causes of acute abdomen during pregnancy with special attention to the diagnosis and treatment of such cases.

2. Acute appendicitis

Appendicitis is the most common cause of acute abdomen during pregnancy, occurring with a usual frequency of 1 in 500–2000 pregnancies, which amounts to 25% of operative indications for non-obstetric surgery during pregnancy [3–5]. This frequency can be explained by the fact that young persons are more prone to acute appendicitis and pregnant women are usually young. Pregnancy does not affect the overall incidence of appendicitis. Appendicitis seems to be more common in the second trimester, with 40% of cases [6]. The difficulties in diagnosis of appendicitis in pregnancy are:

(a) Blunting of signs and symptoms,
(b) changes in appendiceal location as pregnancy advances.

Baer et al. described migration of the appendix as a progressive upward displacement after the third month, reaching the level of the iliac crest at the end of the sixth month. The appendix returns to its normal position by postpartum day 10 [7]. A recent article by Hodjati and Kazerooni did not show that pregnancy changes the location of the appendix [8]. This discrepancy is probably due to the different extents of cecal fixation.

The most reliable symptom is right lower quadrant pain [4,5]. Rebound tenderness and guarding are not very specific because of the distension of the abdominal wall muscles and the interposition of the uterus between the appendix and the anterior abdominal wall. This displacement of the cecum and the appendix, when associated with retrocecal appendix, can result in flank or back pain, which is often confused with a urinary tract infection or pyelonephritis, especially late in the pregnancy. Direct abdominal tenderness is observed most commonly and is only rarely absent [4,6]. Rebound tenderness is present in 55–75% of patients [4–6]. Abdominal muscle rigidity is observed in 50–65% of patients [5]. Psoas irritation (psoas sign) is observed less frequently during pregnancy compared with nonpregnant states [9]. Anorexia and vomiting, very common in the first trimester of pregnancy are not specific and sensitive predictors. Leukocytosis ranging from 10,000 in pregnancy to 20,000 during labor is not very helpful either [10]. Only a granulocytosis (left shift) suggests an infectious etiology such as appendicitis. A urine specimen should be obtained to rule out pyelonephritis or renal calculus, but pyuria can be present in appendicitis.

Graded compression ultrasound is the diagnostic imaging procedure of choice with high sensitivity and specificity in diagnosing appendicitis [11]. Accuracy is demonstrated in the first and second trimesters, while third trimester accuracy was lower because of technical difficulties. Lower sensitivity (28.5%) was present when perforated appendix was found in contrast to nonperforating appendicitis (80.5%) or an appendiceal mass (89%) [11]. Despite these results, other authors presented studies with confirmed pathologic diagnosis of acute appendicitis in 36–50%. In these studies, accuracy of diagnosis is greater in the first trimester, and lower in the second and third, when more than 40% of patients who underwent appendectomy had a normal appendix [3,12]. However, no maternal or fetal morbidity was found to be associated with a normal appendix [12].

Fetal mortality depends on whether appendiceal perforation occurs. With perforation, the fetal loss rate may be as high as 20–35% in contrast to 1.5% if no perforation has occurred [2]. Preterm contractions caused by localized peritonitis are common (83%). Overall, preterm labor and delivery are not common (5–14%), but preterm delivery in the third trimester can be up to 50% [2]. Tamir et al. reported a 66% incidence of appendiceal perforation in patients when surgical delay occurred for greater than 24 h, yet no case of perforation in patients taken to surgery within 24 h of presentation [13]. Maternal mortality is uncommon in the first trimester, but increases with advancing gestational age and is usually associated with a delay in diagnosis and appendiceal perforation. Overall, maternal mortality should be less than 1% when appendicitis is promptly diagnosed and treated. Pregnancy should not deter a surgeon from removing an appendix once the diagnosis is suspected because pregnancy is not affected by removal of a normal appendix [14].

Incisions in open appendectomy (OA) during pregnancy can be a muscle-splitting incision over the point of maximal tenderness, a right pararectal or a midline vertical incision. If laparoscopic surgery is to be performed during pregnancy, open laparoscopy (Hasson technique) is recommended to avoid trocar or Veress needle injury to the uterus. In the late second trimester and beyond laparoscopy becomes technically difficult and a vertical midline incision is advisable. Therapeutic recommendations in cases of acute appendicitis with diffuse peritonitis are:

(a) Cefuroxime, ampicillin, metronidazole, and oxygen preoperatively,
(b) cesarean section because fetal loss is up to 20–36%,
(c) preoperative intubation and ventilation in cases of fetal hypoxia and resuscitation in cases of hypovolemia, and
(d) copious irrigation and use of an intraperitoneal drain.

Without perforation cesarean section is not performed and tocolytics are administered only for perceived or

documented contractions. Delays in diagnosis predispose to more advanced disease with the increased risk for perforation and generalized peritonitis which contribute to increased risk of further complications including premature labor, abortion, and maternal mortality [4,5].

3. Acute cholecystitis

Acute cholecystitis is the second most common cause of acute abdomen during pregnancy, occurring in 1 in 1600–10,000 pregnancies [2]. Cholelithiasis is the cause of cholecystitis in over 90% of cases. The incidence of cholelithiasis in pregnant woman undergoing routine obstetric ultrasound examinations is 3.5–10% [15]. The progesterone-induced smooth muscle relaxation of the gallbladder promotes stasis of bile and increases the risk of cholelithiasis and subsequently of acute cholecystitis [16]. Additionally, elevated levels of estrogen during pregnancy increase the lithogenicity of bile, which further increases the risk of cholelithiasis and acute cholecystitis [17]. Ultrasound findings of the gallbladder in pregnant women show a decrease in the emptying rate and an increase in residual volume after emptying. Two other possible consequences of cholelithiasis, which are the same as in nonpregnant woman, are choledocholithiasis and biliary pancreatitis.

The symptomatology of acute cholecystitis is almost identical in pregnant and nonpregnant women. Nausea, vomiting, dyspepsia, intolerance of fatty foods, and an acute onset of a colicky or stabbing pain that begins over the midepigastrium or right upper abdominal quadrant and radiates to the back are typical. Murphy's sign is less common in pregnant women with cholecystitis. Differential diagnosis includes myocardial infarction, acute fatty liver in pregnancy, HELLP syndrome (which is explained in Section 4), acute appendicitis, preeclampsia, acute hepatitis, pancreatitis, peptic ulcer disease, pyelonephritis, pneumonia, and herpes zoster.

Serum levels of direct bilirubin and transaminases may be elevated, as in nonpregnant women. Serum alkaline phosphatase is less helpful in diagnosing acute cholecystitis in pregnancy because estrogen causes elevation of serum alkaline phosphatase (levels may double during pregnancy). Serum amylase levels are elevated transiently in up to a third of patients [18].

Ultrasound is the diagnostic procedure of choice in pregnancy because of its non-invasiveness, speed, and accuracy of approximately 95–98% for detecting gallstones [19]. Acute cholecystitis can be diagnosed with high reliability when classic findings are present: gallbladder calculi, wall thickening (>3 mm), pericholecystic fluid, and the sonographic Murphy's sign (focal tenderness under the ultrasound transducer positioned over the gallbladder) and dilation of intra- and extrahepatic ducts in common bile duct obstruction.

Owing to the high incidence of fetal loss, early studies recommended medical management and delay in operation until after parturition [18]. Recently, surgery as a primary treatment has been used widely because of:

(a) Reduced use of medications,
(b) recurrence rate during pregnancy of 44–92%, depending on the trimester of presentation,
(c) shorter hospital stay, which did not include hospital days for subsequent cholecystectomy, and
(d) minimizing the development of potentially life-threatening complications such as perforation, sepsis, and peritonitis, which are all indications for surgical treatment [20].

In addition, non-operative management of symptomatic cholelithiasis increases the risk of gallstone pancreatitis up to 13% [21], which causes fetal loss in 10–20% of cases [22]. Non-operative management has also been associated with higher incidences of spontaneous abortions, preterm labor, and preterm delivery than among those undergoing cholecystectomy [23]. Two surgical procedures are used: laparoscopic and open cholecystectomy. In the third trimester, premature onset of labor is a common complication of operative intervention. Pneumoperitoneum at 10–12 mmHg, used in laparoscopic procedures in nonpregnant women, can safely be used in pregnant women. The recommendation is to perform laparoscopic cholecystectomy in the first, second, and early in the third trimester, if indicated, because the procedure is safe for both the mother and the fetus [21]. The open technique (Hasson technique) is necessary for trocar insertion to minimize organ injuries. Transvaginal ultrasound for fetal assessment is ideal during laparoscopy. In general, maternal mortality is low and complications are not significantly increased compared with those operated on in an emergency (open or laparoscopic) who are not pregnant. Both mother and fetus continue to be managed safely by the monitoring of maternal end-tidal carbon dioxide intraoperatively [24] and fetal heart rate before and after surgery [23,25].

There is disagreement on the use of operative cholangiography in the pregnant patient. Current Society of American Gastrointestinal Endoscopic Surgery (SAGES) recommendations are: if acute cholecystitis with symptomatic choledocholithiasis is evident, then open cholecystectomy with choledochotomy and extraction of the calculi is performed. Cholangiography is then performed after the childbirth if pregnancy at an advanced stage. Cholangiography in early-stage pregnancy should be performed after the period of fetal organogenesis. Pelvic lead shielding is used to protect the uterus during intraoperative cholangiography (IOC), which is indicated in pregnancy after the period of fetal organogenesis [26]. IOC did not correlate with preterm delivery or adverse fetal outcomes and is used in more than 26% of laparoscopic cholecystectomies [25]. IOC is used less often in pregnant than in nonpregnant

women. For those patients with common bile duct stones, flexible fiber optic choledochoscopy was done as part of ductal stone clearance whose use eliminates the need for IOC. The frequency of choledocholithiasis in pregnancy requiring intervention has been reported to be as low as 1 per 1200 deliveries [27]. Complications of choledocholithiasis (acute pancreatitis and cholangitis) can significantly increase morbidity and mortality, with up to 15% maternal deaths and 60% fetal loss in acute pancreatitis during pregnancy [27].

Another issue is the use of ERCP (endoscopic retrograde cholangiopancreatography) procedures during pregnancy. Radiation exposure using ERCP procedures during pregnancy are minimized by direct cannulation with a sphincterotome and bile aspiration before using irradiation exposure to verify the bile duct site of obstruction [28]. Videotapes have been used to capture fluoroscopic images, thus obviating the need for additional radiation exposure. ERCP without radiation avoids the need for maternal protective lead shielding during the procedure. It also eliminates the need for fluoroscopy. If needed, the use of ultrasound guidance of catheters during sphincterotomy obviates the need for fluoroscopy [29].

4. Hepatic rupture

Liver disease is rare in pregnancy. Diseases of the liver in pregnancy can be divided into those that occur as a consequence of pregnancy and those that occur simultaneously with pregnancy, but are not specifically related to the pregnancy. The first category consists of a spectrum of disease that occurs in association with pregnancy-related hypertension: intrahepatic cholestasis of pregnancy, acute fatty liver of pregnancy (AFLP) and the HELLP syndrome (associated with severe eclampsia and pre-eclampsia and characterized by hemolysis, elevated liver enzymes, and low platelet levels).

Acute fatty liver of pregnancy is a rare disorder whose onset occurs typically in the third trimester and is characterized clinically by the nausea, vomiting, moderate enzyme elevations, significant coagulopathy, hypofibrinogenemia, hypoglycemia, and hyperbilirubinemia [30]. Maternal and fetal mortality rates have been reported to be as high as 80% in the past [31]. However, recent reports have shown a decreasing trend in mortality rates, because of increased awareness of the clinical entity and earlier recognition of the disease [30]. Complications of AFLP include acute renal failure, liver failure, acute respiratory distress syndrome, hemorrhage because of disseminated intravascular coagulopathy, and pancreatitis [30].

All pregnant women with above mentioned conditions are at risk of spontaneous liver rupture, which is often diagnosed late, carries a very high risk of mortality for both the mother and the fetus if not identified early and treated aggressively. Therapy for AFLP is directed toward delivery and supportive care, with resolution observed in most cases.

Hepatic rupture is usually manifest late in the third trimester. Patients complain of symptoms related to hypertension. There may be a history of nausea, vomiting or epigastric discomfort. Laboratory tests show only elevated liver transaminases. Mild jaundice and elevation of alkaline phosphatase may be present. The coagulation profile is abnormal and thrombocytopenia is present. If subcapsular hematoma is present it is diagnosed by ultrasound. On the other hand, hepatic rupture is characterized by the presence of shock and this situation is a surgical emergency requiring termination of the pregnancy and operative control of the hemorrhage in order to prevent the death of the mother. Fetal outcome is catastrophic even in term pregnancy [32].

In patients with a viable pregnancy, liver hematoma and coagulopathy who are otherwise stable, conservative therapy with bed rest, treatment of eclampsia, fetal monitoring, and correction of the coagulopathy is initiated. Serial ultrasound evaluations should be performed. Patients managed conservatively are in the minority, but have the best outcome. Delivery is most commonly by cesarean section, which also allows operative assessment of the extent of the liver hematoma.

In patients with hepatic rupture urgent resuscitation is followed by operation, during which it is necessary to terminate the pregnancy regardless of the viability of the fetus. Liver packing is the primary treatment for ruptured liver hematoma and is associated with a better result than surgical resection. Liver packing is also a temporary measure in inexperienced hands when surgery is indicated, until transportation to specialized centers where definitive operation is undertaken.

Mortality rates range from 40 to 60% for both the mother and the fetus [32]. This is due in part to the delayed diagnosis with the mother in hemorrhagic shock, and to the fact that the mother is critically ill with a metabolic imbalance and coagulopathy.

5. Intestinal obstruction

Bowel obstruction is the third most common cause of acute abdomen during pregnancy, occurring in 1 in 1500–16,000 pregnancies [33]. Adhesions are found in 60–70% of cases (previous abdominal surgery, pelvic surgery, or pelvic inflammatory conditions) [34], followed by volvulus, which occurs in approximately 25% of cases [35]. This differs from the incidence of volvulus in nonpregnant patients, which is 3–5% [36]. The incidence of cecal volvulus is 25–44% of all cases of mechanical obstruction [36], increases with the duration of gestation and is the greatest at times of rapid uterine size changes, especially from 16 to 20 weeks, when the uterus becomes an intra-abdominal organ, from 32 to 36 weeks, as the fetus enters the pelvis, and in the puerperium, when uterine size changes rapidly again. As the uterus enlarges during pregnancy, it raises any redundant or abnormally mobile cecum out of the pelvis, increasing the

incidence of the cecal rotation around a fixed point [37]. A similar pathophysiologic process is found in obstructions secondary to small bowel volvulus, which occurs most commonly in the third trimester or puerperium [1,34]. Small bowel volvulus occurring alone represents 9% of all cases of intestinal obstruction during pregnancy [38]. Other causes, such as intussusception (5%), hernia, cancer, and worsening diverticulitis/diverticulosis, are rare [35,39]. The incidence of bowel obstruction has increased over the years because of an increase in the number of abdominal operations performed that cause adhesions. Perdue et al. described overall maternal mortality of 6%, fetal mortality of 26%, and bowel strangulation requiring resection of 23% [34]. The mortality rate of intestinal obstruction is much higher during pregnancy than in the general population. There is dramatic progression of fetal mortality as gestation continues. Most commonly, obstruction occurs in the third trimester, when maternal mortality can be as high as 10–20%.

The varied symptoms of pregnancy itself may be a source of confusion leading to a delay in diagnosis and subsequently to an increase in complications. The uterus, cervix, and adnexa share the same visceral innervation as the lower ileum, sigmoid colon, and rectum, and distinguishing between pain of gynecologic and gastrointestinal origin is often difficult [40]. Typical symptoms are as in nonpregnant women:

(a) Crampy abdominal pain: in the case of high obstruction with intervals between attacks of 4–5 min and diffuse, poorly localized upper abdominal pain, or in the case of low obstruction with intervals of 15–20 min and low abdominal or perineal pain,
(b) obstipation, and
(c) vomiting [34].

During the first 14–16 weeks of a normal intrauterine gestation, approximately 50% of pregnant women complain of nausea and 33% experience emesis [41]. Nausea and vomiting usually resolve near the end of the first trimester. In cases of severe, persistent vomiting, particularly if it begins after this time period, excluding intestinal obstruction as a cause is very important. Fever, leukocytosis, and electrolyte abnormalities increase the likelihood of intestinal strangulation.

Plain abdominal films with the presence of air–fluid levels or progressive bowel dilatation in serial films obtained at 4–6 h intervals are diagnostic, as in nonpregnant women. Perdue et al. found radiologic evidence of intestinal obstruction in 82% of pregnant patients [34]. The diagnosis of cecal volvulus can be made with abdominal plain X-ray with 95% sensitivity. A characteristic coffee-bean deformity may be seen directed toward the left upper quadrant. Because the cecum is mobile, the dilated cecal loop may actually appear anywhere in the abdomen [42]. Radiological studies with the use of contrast media should be performed if bowel obstruction is still suspected in the absence of typical findings on plain abdominal films. The significant maternal and fetal mortalities associated with obstruction outweigh the potential risk of fetal radiation exposure [37].

Colonoscopy carries a high rate of diagnosis and reduction in volvulus of the sigmoid colon (60–90%). However, its rate of reduction in cecal volvulus is low. Colonoscopy has been employed to confirm or exclude the diagnosis of colonic volvulus, to detect the danger signs of mucosal ischemia and to avoid the need for emergency surgery by reducing the volvulus in cases in which ischemia is not present. Because of a >50% recurrence, delayed surgery after delivery is mandatory in all cases [43]. During pregnancy, surgery is safest before the third trimester. The finding of bloody intestinal contents or cyanotic mucosa suggests the need for termination of the colonoscopic procedure and prompt laparotomy [43]. The mortality rate has been reported to be 33% when gangrenous bowel is present. The presence of gangrenous bowel makes immediate resection mandatory [42].

The therapeutic algorithm is the same for pregnant and nonpregnant women. Conservative therapy is indicated first with fluid and electrolyte replacement, nasogastric suction for bowel decompression and enemas. Fetal monitoring and maternal oxygen saturation levels need to be closely evaluated.

Unsuccessful medical treatment or fever, tachycardia and progressive leukocytosis, in association with abdominal pain and tenderness warrant early surgical exploration. A midline vertical incision is recommended. If necrotic bowel is identified, segmental resection is indicated. Intravenous resuscitation of fluid and electrolytes is continued for at least 5 days. The surgical techniques described for cecal volvulus are cecostomy, cecopexy, resection with ileostomy, and resection with primary anastomosis [36]. Laparoscopic cecopexy for primary intermittent cecal volvulus may be an alternative to laparotomy in selected cases, but is not indicated in the emergency situation [44]. The cecopexy technique has low complication rates and recurrence rates of 0–8% [45]. However, resection is usually favored for all cases of cecal volvulus in which cecopexy is technically difficult. Surgical resection eliminates the possibility of recurrence, usually resulting in low morbidity and mortality, and is always indicated if bowel necrosis is evident [46]. Fetal death rates following maternal intestinal obstruction are between 20 and 26% [39]. Maternal mortality can range from 6 to 20% [1,39].

6. Acute pancreatitis

Acute pancreatitis occurs in 1 in 1000–3000 pregnancies, usually late in the third trimester or in the early postpartum period [47]. One hypothesis to explain the frequent occurrence of acute pancreatitis in the third trimester of pregnancy is increased intra-abdominal pressure on the biliary ducts. Cholelithiasis is the most common cause and accounts

for 67–100% of cases, followed by alcohol abuse [47]. Other causes are abdominal surgery, blunt abdominal trauma, infections (viral, bacterial, parasitic), penetrating duodenal ulcer, connective tissue diseases, and hyperparathyroidism. Hyperlipidemic pancreatitis accounts for 4–6% of acute pancreatitis during pregnancy [48]. It usually occurs in the second and the third trimesters of primipara women who have hyperlipoproteinemia. This condition has been reported to lead to a high rate of fetal mortality (up to 37%), primarily due to premature birth [49]. Most cases of hyperlipidemic pancreatitis in pregnancy are associated with either type I or V familial hyperlipoproteinemia [49]. Pregnancy is normally associated with hyperlipoproteinemia, and may be associated with an increase of as much as 2.5-fold in very low-density lipoprotein triglycerides over pre-gestational levels in the middle of the third trimester [50]. An increase in cholesterol of 25–50% occurs primarily as a result of higher blood levels of estrogen [51]. The level of triglycerides required to induce acute pancreatitis is between 750 and 1000 mg/dl [52]. The total serum triglyceride level during pregnancy is usually less than 300 mg/dl. Acute pancreatitis associated with preeclampsia/eclampsia is rare [53]. Preeclampsia is associated with microvascular abnormalities that may involve cerebral, placental, hepatic, renal, and splanchnic circulation, and thus can cause acute pancreatitis. Another predisposing factor for the development of acute pancreatitis is AFLP, but this pathology is rare (see Section 4). An important observation is that pancreatic abnormalities typically appear after hepatic and renal dysfunction and that laboratory evidence of renal dysfunction peaked after the worst hepatic enzyme abnormalities for most patients. It is also important to bear in mind this entity because maternal mortality of this pathology is as high 17% and fetal mortality reaches 25% [54].

Typical symptoms are as in nonpregnant women and include sudden and severe epigastric pain radiating to the back, postprandial nausea and vomiting, and fever. The patient is often found lying in the fetal position with flexed knees, hips, and trunk. Bowel sounds are usually hypoactive, secondary to paralytic ileus, and the abdomen is diffusely tender. Differential diagnosis includes all pathologic conditions in the differential diagnosis of acute cholecystitis (see Section 3).

Laboratory investigations are the same as in nonpregnant women. In their study, which included a matched control group, Karsenti et al. confirmed that the values of serum amylase activity are similar in pregnant and nonpregnant women. The same group also concluded that serum lipase activity was significantly lower during the first trimester of pregnancy compared with nonpregnant women and compared with those in the third trimester. Serum lipase activity was not statistically different between pregnant and nonpregnant women during the second and third trimesters. Their conclusion is that an increase in serum amylase and lipase activities during pregnancy should be taken into account, as in nonpregnant women, and that lipase levels are a better predictor of acute pancreatitis that amylase levels [55]. Several conditions may result in the elevation of serum amylase and lipase levels, which include cholecystitis, bowel obstruction, hepatic trauma, perforative duodenal ulcer. Therefore, diagnostic recommendations are: serial measurements of serum amylase and lipase levels, and the calculation of an amylase to creatinine clearance ratio. This ratio, which is generally low in pregnant woman, was found to be elevated in pregnant women with pancreatitis. A ratio greater than 5% suggests acute pancreatitis [56]. Acute pancreatitis is associated with pulmonary findings in 10% of patients, but the cause is unknown. Pulmonary signs often include hypoxemia, which can lead to full-blown adult respiratory distress syndrome. A pulse oximeter reading should be obtained. The severe hypoalbuminemia – out of proportion to the degree of proteinuria, hypocalcemia, and generalized anasarca – should raise the suspicion of some inflammatory condition that can result in the capillary leak syndrome, including acute pancreatitis [57]. Ultrasound is useful for ruling out cholelithiasis, pancreatic pseudocysts, and abscesses. Still, there are no guidelines for the use of CT in complicated and doubtful cases. Ranson developed criteria for the classification of severity of acute pancreatitis based on nonpregnant persons. These criteria are often used as a guide when treating gravid women with pancreatitis to judge the severity and recovery progress in pregnant women [58].

Medical management is the same as in pancreatitis in nonpregnant women and consists of bowel rest, fluid/electrolyte resuscitation, and the use of analgesics and antispasmodics. Bowel rest is achieved by the use of nasogastric suction, intravenous fluids are used for correction of fluid/electrolyte abnormalities, and pethidine (merperidine) or tramadol are used for pain relief instead of morphine, because these two analgesics do not produce spasms of the sphincter of Oddi [59]. If fever persists and sepsis occurs or is suspected, broad-spectrum antibiotics should be started. Because acute pancreatitis in pregnancy is a critical condition it is best managed in an intensive care unit. Most patients will respond to medical management within a few days. Clear liquid diet can be started on day 4 or 5. The management of gestational hypertriglyceridemic pancreatitis lies in the correction of lipoprotein metabolism disturbances. Dietary fat restriction, lipid-free parenteral nutrition or lipoprotein apheresis and plasmapheresis have all been used to achieve this [60]. Antihypertriglyceridemic drugs, such as fibric acid derivatives, should not be considered, due to the possibility of teratogenic effects.

ERCP and endoscopic sphincterotomy are techniques used to treat gallstone-related pancreatitis (see Section 3) [28]. Increased serum amylase levels are often elevated transiently following this procedure.

Surgical management is reserved in cases refractory to medical management. Unified data for maternal mortality are lacking. The relapse rate for gallstone-related pancreatitis is higher than for other causes: up to 70% with conservative treatment can only be associated with a significant fetal loss rate of between 10 and 20% [22].

7. Blunt trauma

Trauma affects 6–7% of pregnancies in the USA and is the leading cause of non-obstetric maternal death, with 0.3% of pregnant women reported to require hospital admission because of trauma [61]. The most common causes of blunt trauma are motor vehicle accidents followed by physical abuse and accidental falls [61,62]. The frequency of sexual abuse or rape as a cause of blunt trauma in pregnancy decreases as pregnancy progresses. Physical violence occurs in as many as 10% of pregnant women [63].

Pathophysiology is dependent on anatomical alteration of intra-abdominal organs. Pressure transmission to the uterus causes placental abruption and uterine rupture, which are primary causes of fetal death in motor vehicle accidents. Up to 40% of severe blunt trauma is associated with placental abruption. The propensity toward uterine rupture increases with advancing gestational age and the severity of the direct traumatic abdominal force of injury. Direct fetal injury from blunt trauma most commonly involves damage to the fetal skull and brain when pelvic fracture occurs in association with cephalic presentation of the fetus. In motor vehicle accidents, the most common cause of fetal death is maternal death [64]. The same study reported a reduction in the maternal death rate from 33 to 5% with the use of two-point restraint. The National Highway Traffic Safety Administration does not consider pregnancy as an indication for the deactivation of air bags. Direct fetal injuries and fractures complicate less than 1% of cases of severe blunt abdominal trauma in pregnant women. The rate of fetal mortality after maternal blunt trauma is 3.4–38.0% [61,65], mostly from placental abruption, maternal shock, and maternal death.

The mean Injury Severity Score (ISS) was lower in pregnancies resulting in fetal survival compared with the ISS in pregnancies resulting in fetal death. The optimal cut-off point for predicting fetal death was ISS ≥ 4 [65,66]. The ISS did not perform well in discriminating between injured pregnant women with and without placental abruption [66]. This means that relatively minor injuries were associated with adverse pregnancy outcomes. Of the other scoring systems only the Glasgow Coma Scale [65] and arterial blood pH [67] have been good predictors of fetal death. A more comprehensive injury assessment tool for the pregnant trauma population, including fetal heart rate monitoring and obstetric ultrasound as well as injury severity scoring and maternal arterial blood acid–base status measurements, would likely improve the predictive accuracy of adverse outcomes among pregnant trauma patients [66].

Rapid maternal respiratory support is critical; anoxia occurs more quickly in advanced pregnancy because of the changes that occur in respiratory physiology during pregnancy [68]. Evaluation of the fetus should begin only after the mother has been stabilized. Supplementary oxygen and intravenous fluids are administered initially, and are continued until hypovolemia, hypoxia, and fetal distress resolve. These measures maximize uterine perfusion and oxygenation for the fetus [69].

A topic for discussion is female trauma patients evaluated in the emergency department with altered mental status or unable to convey to the health care providers their pregnancy status, and women who are unaware of their pregnancy at the time the traumatic injuries are sustained. This is termed *incidental pregnancy*. New or real incidental pregnancy includes only women with normal mental status who are unaware of their pregnancy. One of the biggest studies on this topic concluded that many centers have eliminated the use of rapid urine pregnancy testing because of quality control issues. Although the serum b-HCG test is the gold standard, it may take hours. Most urine pregnancy kits may reveal positive results 3 or 4 days post-implantation, with a 98% sensitivity by 7 days [70]. The incidence of incidental pregnancy was 11.4% and the overall fetal mortality for all incidental pregnancies was 77%, but the mortality rate was 100% in the newly diagnosed incidental pregnancy group. Three of the nine fetal deaths were the result of an elective abortion and the remainder were the result of spontaneous abortion. The reason for elective pregnancy termination was fear of an abnormal fetus resulting from the combination of the injury and the radiation exposure they received. Each of these patients had received proper counseling on the effects of prenatal radiation exposure.

8. Penetrating trauma

The most common causes of penetrating trauma are gunshot and stab wounds, and unlike blunt trauma these are rarely associated with maternal mortality, but with perinatal mortality of 47–71%. Fetal injury is documented in 59–89%. After the first trimester, the expanding uterus plays a ‘‘protective’’ role for other abdominal organs. The maternal death rate from gunshot wounds to the abdomen is significantly lower than in nonpregnant women (3.9% versus 12.5%). The death rate from abdominal stab wounds is also diminished.

Algorithms for the assessment of maternal status are the same in pregnant as in nonpregnant women, following the ABCs of basic and advanced trauma life support. The additional assessment in pregnant women includes fetal status. Cardiotocography is a much better diagnostic procedure than ultrasound for assessing the risk of suspected placental abruption due to trauma. Lateral displacement of the uterus is an important initial measure in pregnancies of longer than 24 weeks’ gestation. Pressor/inotropes may reduce uteroplacental blood flow; however, in the critically ill gravida, their use may be necessary to save the mother’s life [69].

The recommendation is that fetal doses below 100 mGy should not be considered a reason for terminating a pregnancy [71]. Ultrasound is used for the assessment of fetal gestational age, fetal heart activity, fetal activity,

amniotic fluid volume, and maternal intraperitoneal fluid if suspected. The presence of uterine contractions should raise the suspicion of placental abruption. If there is no evidence of uterine contractions, vaginal bleeding, uterine tenderness or ruptured amniotic membranes, and maternal status is stable, fetal monitoring can be discontinued after 4 h if the fetal heart rate is normal [62].

Traditionally, the presence of a penetrating abdominal injury during pregnancy necessitates surgical exploration. Laparotomy for maternal indications is not an indication for cesarean section. A cesarean section should be performed for fetal distress, direct perforating uterine injury or for maternal indications if abdominal exploration and surgical intervention cannot be carried out because of a gravid uterus.

A special problem in trauma with hemorrhage is Rh immunization. Direct blood contact between mother and fetus is assessed with the Kleihauer–Betke test (acid elution for fetal hemoglobin), which allows accurate determination of the amount of Rh immunoglobulin to administer to Rh-negative women. One ampoule of 300 μg D-immunoglobulin protects against hemorrhage of less than 30 ml. The American College of Obstetrics and Gynecology recommends administering D-immunoglobulin to all sensitized D-negative pregnant patients evaluated for abdominal trauma [72]. Perimortem cesarean section should be considered in the trauma patient who is unresponsive to cardiopulmonary resuscitation. Results show that 75% of surviving infants delivered within 5 min of maternal death were neurologically intact [68]. The recommendation is to perform 4 min of resuscitation and if the patient has not responded, to perform emergency abdominal delivery. This rule is called the ‘‘5-minute rule’’.

9. Conclusion

Advances in technology used in clinical medicine make precise diagnosis of the acute abdomen in pregnant women earlier and more accurately. Abdominal ultrasound is the procedure of choice in many situations because of its non-invasiveness, speed, and accuracy. Also, therapeutic advances, especially using laparoscopic and endoscopic procedures, open new possibilities for treating acute abdominal conditions during pregnancy. Several series have now been published documenting the use of laparoscopy in pregnant women with an acute abdomen in over 500 cases, yet long-term follow-up data are scarce. Ultrasound and laparoscopy (and other modalities too) significantly influenced diagnostic and therapeutic algorithms, but unified international recommendations have not yet been established.

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