RadioGraphics

Imaging after Cesarean Delivery: Acute and Chronic Complications[1]

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CME FEATURE

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LEARNING OBJECTIVES FOR TEST 4

After completing this journal-based CME activity, participants will be able to:

- Distinguish the expected postoperative findings following cesarean delivery from those that require treatment.
- Discuss the limitations of uterine US after cesarean delivery due to adhesions that tether the lower uterine segment to the anterior abdominal wall.
- List chronic complications related to the cesarean delivery scar.

TEACHING POINTS

See last page

Cesarean delivery is a commonly performed operation and accounts for nearly one-third of all births in the United States. Although it is a safe procedure, cesarean delivery has a variety of acute and chronic complications that prompt imaging with ultrasonography (US), computed tomography, and magnetic resonance imaging. Acute complications include hematomas in specific locations that are unique to the procedure, as well as a variety of infections. A bladder flap hematoma occurs in the space between the bladder and the lower uterine segment, whereas a subfascial hematoma is an extraperitoneal collection located in the prevesical space posterior to the rectus muscles and anterior to the peritoneum. Puerperal infections after cesarean delivery include abscesses, wound infections and dehiscence, uterine dehiscence and rupture, and pelvic thrombophlebitis. The prevalence of chronic complications related to the healed cesarean delivery scar is unknown, but the scar may result in technical limitations for pelvic US due to the adhesions between the anterior lower uterine segment and the anterior abdominal wall. The cesarean delivery scar also leaves the patient susceptible to several unique diagnoses. A cesarean scar "niche" is a tethering of the endometrium that can serve as a reservoir for intermenstrual blood and fluid. Intrauterine devices can be malpositioned in the cesarean delivery scar, and endometrial implants can develop in the abdominal wall years after surgery. These patients are also at increased risk for implantation abnormalities including cesarean scar ectopic pregnancy, retained products of conception, and placenta accreta. Familiarity with the normal postoperative findings following cesarean delivery is necessary to recognize acute and chronic complications, which are being encountered with increasing frequency.

Abbreviations: IUD = intrauterine device, RPOC = retained products of conception, 3D = three-dimensional

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Introduction

Cesarean delivery is the most commonly performed major abdominal operation in women. The rate varies between low-income and affluent countries, with global estimates of 15% worldwide, ranging from a low of 3.5% in Africa, to 33% in the United States, to a high of 43.9% in Brazil (1–3). Although significant acute complications are uncommon, given the increasing prevalence of the procedure, imaging of these patients has become more frequent. In one series, the overall complication rate was 14.5%, and the most common complication was infection (13.3% of cases) (4). Endometritis was the most common infection (6.6% of cases), with wound infections occurring in 1.6% of cases. Elective operations had fewer complications (4.7% of cases) than did emergency operations (24.2%) (4). Risk factors that predispose patients to postoperative morbidity include prolonged ruptured membranes and increased duration of labor prior to surgery, as well as anemia and obesity. Typical symptoms that prompt imaging in the immediate postoperative period include fever, a dropping hemoglobin level, unexpectedly heavy vaginal bleeding, and pain. Ultrasonography (US) and, in particular, computed tomography (CT) are most often used to diagnose acute findings such as hematomas, abscesses, wound infections and dehiscence, uterine dehiscence and rupture, and pelvic thrombophlebitis.

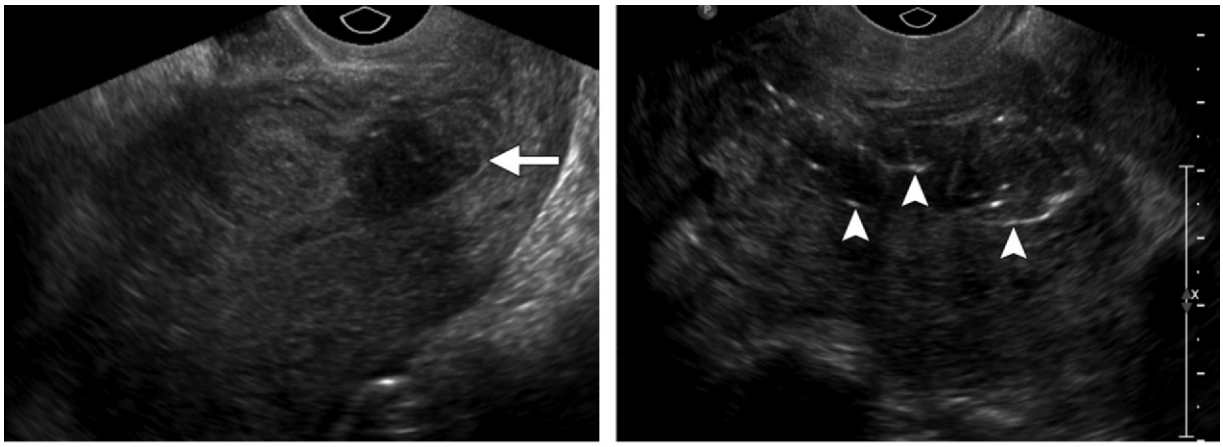
The actual prevalence of symptoms related to a healed cesarean delivery scar is unknown, but these symptoms may include intermenstrual bleeding and abdominal wall or pelvic pain. Pregnant patients with prior cesarean delivery are at risk for ectopic pregnancy at the scar, a rare but increasingly reported complication requiring a high degree of suspicion for the diagnosis. Other scar-related abnormalities include retained products of conception (RPOC) at the cesarean delivery scar, placenta accreta, malpositioned intrauterine devices (IUDs), and endometriosis. Evaluation of these chronic complications may require US, sonohysterography, magnetic resonance (MR) imaging, and occasionally CT. In this article, we briefly review the surgical technique of cesarean delivery, discuss the expected imaging findings after cesarean delivery, and describe the findings of the more common acute and chronic complications associated with this procedure.

Surgical Technique of Cesarean Delivery

There are many variations of the surgical technique; however, the most commonly performed is the low transverse cesarean delivery via a Pfannenstiel or Joel-Cohen skin incision. A scalpel is used to incise the skin with further blunt dissection to the fascial layer. The fascia is opened sharply in the transverse plane, followed by blunt separation of the rectus muscles and meticulous entrance into the peritoneum to minimize the risk of inadvertent injury to the bowel, bladder, or other adherent structures. The presence of dense intraperitoneal adhesions requires extensive dissection to avoid injuring organs and to minimize bleeding. A bladder flap may be created by reflecting the bladder peritoneum inferiorly. A small low transverse incision is made through the myometrium after the surgeon ascertains the general location of the fetal lie. Certain surgical or obstetric indications may require a vertical uterine incision, commonly referred to as the "classical cesarean incision." The baby is delivered with external fundal pressure, followed by delivery of the placenta. Next, the myometrial layer is closed using a single- or double-layer suture, followed by the fascial and skin layers. Some surgeons may choose to reapproximate the bladder flap and close the peritoneum, but the rectus muscles are not reapproximated (5). Recent preliminary data suggest that placement of adhesion barriers or peritoneal closure can reduce adhesions, but further investigation is required (6).

Normal Acute Findings after Cesarean Delivery

A spectrum of imaging findings in the uterus after cesarean deliveries may appear unusual but are considered to be within normal limits or of no clinical significance. The normal appearance of the incision at US has been described. Baker et al (7) used transabdominal US to prospectively study 36 asymptomatic patients 2 days after cesarean delivery to distinguish the normal appearance of the lower uterine incision from significant hematoma. Koutsougeras et al (8) used endovaginal US to examine 75 asymptomatic women 3 days after cesarean delivery to determine criteria for natural healing of low transverse cesarean incisions. In both studies, the incision was identified as an oval region that was centrally located between the bladder and the uterus and was iso- to slightly hypoechoic relative to the myometrium. Both studies also



a. b.

Figure 1. Normal appearance of a cesarean delivery incision at US 3 days after surgery. **(a)** Longitudinal endovaginal US image of the uterus demonstrates an oval hypoechoic area (arrow) representing edema at the site of the surgical incision in the anterior lower uterine segment. **(b)** Transverse endovaginal US image shows several punctate and curvilinear hyperechoic foci (arrowheads) representing suture material.

a. b.

Figure 2. Normal postoperative appearance of a cesarean delivery incision at CT. **(a)** Axial contrast material–enhanced CT scan through the pelvis obtained in a 35-year-old woman demonstrates an oval area of low attenuation (*) at the site of the low transverse incision in the anterior lower uterine segment. **(b)** Sagittal reformatted CT image more clearly shows a combination of edema (*) and a small hematoma (arrowhead) at the incision site.

depicted punctate or linear echogenic foci representing sutures in the region of the incision (Fig 1). Although not necessarily considered normal, small hematomas at the uterine incision site should be considered clinically insignificant as long as the size is less than 1.5 cm (7,8).

For CT studies, maximizing technique with intravenously administered contrast material is extremely important given the overlap between normal and pathologic imaging findings after cesarean delivery. Unfortunately, adequate levels of enhancement are often difficult to achieve because of the relative fluid overload related to the pregnancy and surgery. Normal CT findings in the uterus include an oval or triangular area of decreased attenuation in the myometrium in the anterior lower uterine segment. A study by Twickler et al (9) showed that uterine discontinuity is commonly seen at CT in the period immediately following cesarean delivery (Figs 2, 3). At CT, low attenuation within the uterine incision likely represents edema and is

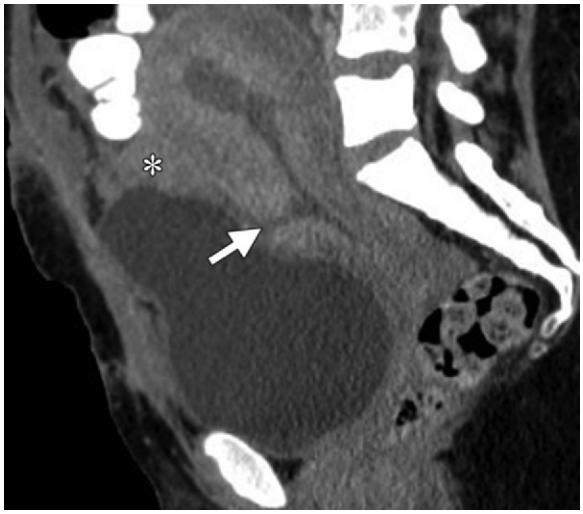


Figure 3. Normal postoperative appearance of a cesarean delivery incision and a small bladder flap hematoma at CT. Sagittal reformatted contrast-enhanced CT image demonstrates a normal low-attenuation incision (arrow) in the anterior lower uterine segment, a finding that is best visualized in the sagittal plane. This uterine discontinuity is secondary to edema at the incision site. The small high-attenuation collection (*) between the urinary bladder and uterus represents an uncomplicated bladder flap hematoma.

a normal finding; therefore, myometrial discontinuity in the first postpartum week should not be interpreted as uterine rupture or dehiscence (9). After cesarean delivery, the uterine cavity is almost always empty, and there should be no significant free fluid in the pelvis if peritoneal irrigation is not performed (10). Endometrial clot and debris will appear as areas of increased echogenicity at US or as hyperattenuating material at CT (Fig 4). These findings can be seen in healthy patients but are also common findings in the setting of endometritis, making the patient's clinical history extremely important for proper image interpretation. General postpartum complications such as RPOC may be visualized (Fig 5). Small amounts of air in the subcutaneous incision, the endometrium, and the urinary bladder (from a Foley catheter) are also routine findings after cesarean delivery. Haziness and stranding or small areas of fluid in the subcutaneous fat can be expected due to the surgical procedure, but no discrete, walled-off fluid collection should be present. Small peritoneal fluid collections such as anterior subfascial hematomas and bladder flap hematomas are generally considered routine and are usually not clinically significant if less than 4 cm in size (10).

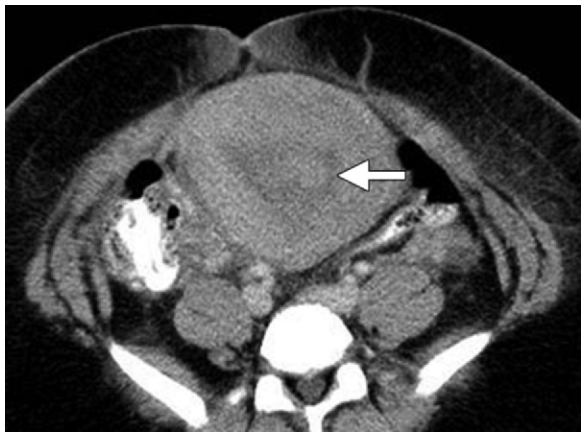


Figure 4. Normal acute postoperative finding at contrast-enhanced CT after cesarean delivery. Axial contrast-enhanced CT scan through the uterus demonstrates high-attenuation material (arrow) representing blood in the endometrial cavity.

Figure 5. Incidentally discovered RPOC in a patient who had recently undergone cesarean delivery. Sagittal reformatted contrast-enhanced CT image demonstrates a small region of hyperenhancement (arrow) in the posterior myometrial-endometrial junction and endometrium, a finding that is in keeping with RPOC. Note the normal postprocedural mixed attenuation of the lower uterine segment incision (arrowhead) secondary to a combination of edema and a small hematoma.

Acute Complications after Cesarean Delivery

Acute complications following cesarean delivery include many of the same types of complications that occur after any surgery, the most common being infection and hemorrhage. Infections include endometritis, wound infection, infected hematoma, and abscess formation. Hematomas can form in the anterior abdominal wound, in the extraperitoneal prevesical space, and around the lower uterine segment incision. A study by Antonelli

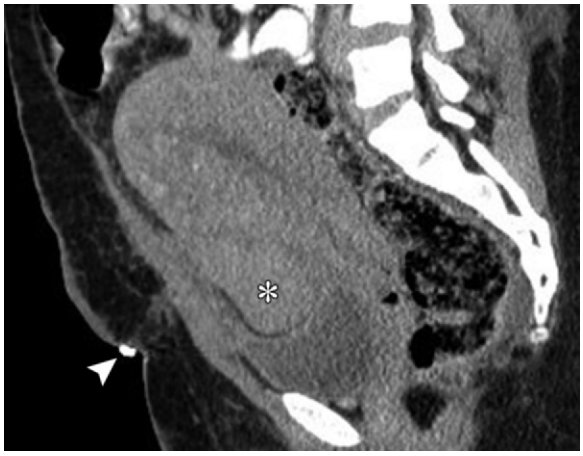


Figure 6. Bladder flap hematoma in a 28-year-old woman who presented with pelvic pain shortly after undergoing cesarean delivery. Sagittal reformatted contrast-enhanced CT image demonstrates a high-attenuation collection (*) anterior to the uterus and indenting the urinary bladder, a finding that represents a bladder flap hematoma. Note the skin staples in the Pfannenstiel incision (arrowhead) and stranding in the anterior abdominal wall from recent surgery.

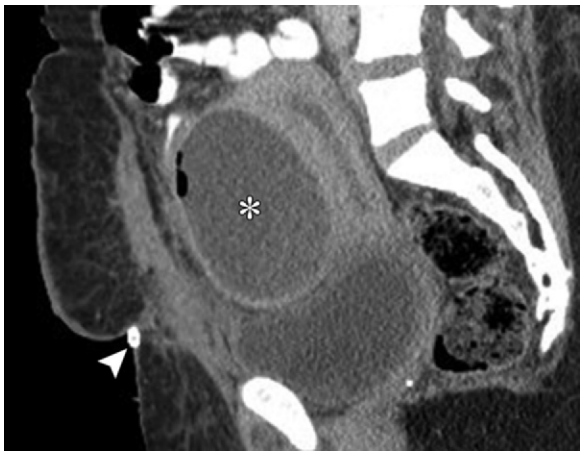


Figure 7. Bladder flap abscess in a 26-year-old woman who presented with fever and abdominal pain 12 days after undergoing cesarean delivery. Sagittal reformatted contrast-enhanced CT image demonstrates a rim-enhancing, gas-containing collection (*) anterior to the uterus and superior to the bladder. The patient required hysterectomy for treatment. Note the skin staples and mild stranding in the anterior abdominal wall (arrowhead) from recent surgery.

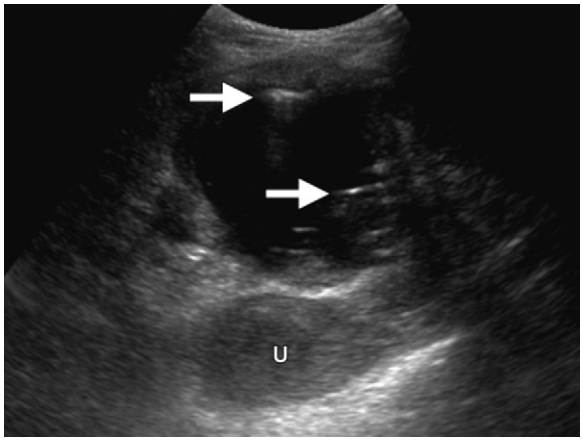


Figure 8. Bladder flap abscess in a 21-year-old woman who had undergone cesarean delivery 9 days earlier. Transverse transabdominal US image demonstrates a complex collection anterior to the uterus *(U)* containing numerous echogenic foci (arrows) representing gas bubbles. The bladder (not shown) was displaced inferiorly by the abscess.

et al (11) detected fluid collections in the abdominal wall or pelvis in 48% of patients after cesarean delivery, and no association was found between the presence, location, or size of a fluid collection and postoperative fever or serous discharge.

There are several acute complications related to cesarean delivery, including bladder flap hematoma, subfascial hematoma, uterine dehiscence, uterine rupture, and ovarian and pelvic septic thrombophlebitis.

Bladder Flap Hematoma

Bladder flap hematomas may occur after cesarean deliveries performed with a low uterine transverse incision. The peritoneum is incised between the myometrium and bladder and reflected inferiorly. If bleeding occurs at this site, a hematoma known as a bladder flap hematoma forms between the urinary bladder and the lower uterine segment. US will show a hyperechoic collection between the uterus and the urinary bladder. At CT, the hematoma is somewhat hyperattenuating and is seen in the same location, with or without mass effect (Figs 3, 6). Bladder flap hematomas can be considered normal if they are less than 4 cm in size (as mentioned earlier), and they may occur in up to 50% of patients (10). Bleeding from the uterine incision is usually confined by the overlying peritoneum but can spread to the broad ligaments, retroperitoneum, and peritoneum. At CT, superimposed infection of bladder flap hematomas will appear as rim-enhancing, gas-containing fluid collections with or without multiple internal septa, located between the urinary bladder and uterus in the expected region of the simple bladder flap hematoma (Fig 7). US will show a well-circumscribed fluid collection between the bladder and uterus with internal debris and, potentially, gas, which appears as echogenic foci causing "dirty" posterior shadowing (Fig 8). Surgical evacuation of significant bladder flap hematomas may require incision of the peritoneum.

Subfascial Hematoma

A subfascial hematoma is an extraperitoneal hemorrhage that arises from the inferior epigastric vessels and their branches. Blood can accumulate in the prevesical space, posterior to the rectus and transversalis muscles and anterior to the peritoneum continuous with the space of Retzius. An acute hematoma has a higher attenuation at CT (70–90 HU) (Fig 9), and contrast-enhanced CT may be used to document contrast material extravasation in the setting of active bleeding (12). US demonstrates either a cystic or a complex collection anterior to the urinary bladder (13). Significant blood loss can occur with subfascial hematomas, since up to 2.5 L may accumulate in this large potential space without a palpable abnormality (14). It is important to be able to recognize and distinguish between subfascial and bladder flap hematomas because surgical evacuation of a bladder flap hematoma may require incision of the peritoneum, whereas a subfascial hematoma can be evacuated without opening the peritoneum (14). Differentiating subfascial hematomas from superficial wound hematomas is also important given the potential for significant blood loss with subfascial hematomas. The rectus muscle serves as a landmark in distinguishing between these two types of hematomas, with the superficial wound hematoma located anterior to the rectus muscle and the subfascial hematoma located posterior to the muscle (13). CT can also demonstrate more superficial complications of the skin, as well as subcutaneous wounds. Separation of the abdominal wall at the site of incision indicates dehiscence of the skin incision (Fig 10). Although a small amount of subcutaneous gas can be expected, organizing areas of subcutaneous gas and fluid indicate more extensive infection and abscess formation.

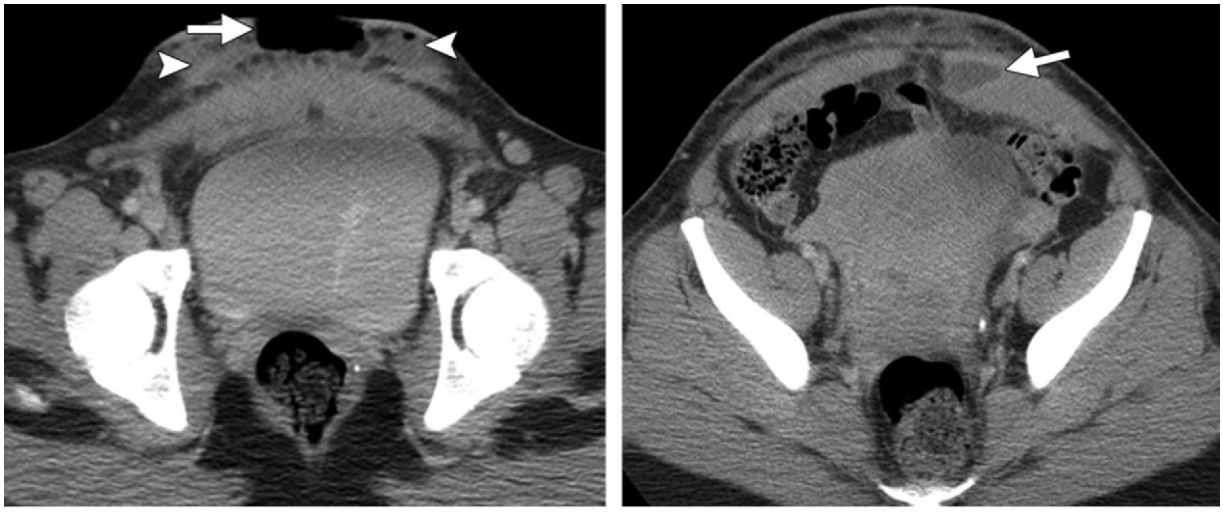
Teaching Point

Figure 9. Acute subfascial hematoma in a patient who had undergone cesarean delivery 3 days earlier. Sagittal reformatted contrast-enhanced CT image demonstrates a high-attenuation collection (arrows) posterior to the rectus muscles and anterior to the urinary bladder, a finding that is consistent with a subfascial hematoma.

Uterine Dehiscence

Teaching Point

Uterine dehiscence is characterized by incomplete rupture of the uterine wall, usually involving the endometrium and myometrium but with an intact overlying serosal layer (10). Uterine dehiscence is a very difficult imaging diagnosis because of overlap with the normal appearance of the uterine incision after cesarean delivery. Studies have shown that the clinical diagnosis of uterine dehiscence after cesarean delivery correlates poorly with CT findings (9). In a study by Rivlin et al (15), the imaging studies of seven patients with surgically proved uterine dehiscence failed to demonstrate the finding. CT features in these patients were nonspecific and included free fluid, bladder flap hematoma, pleural effusion, bowel distention, and intrahepatic abscess (15). Brown et al (16) found CT to be rather unhelpful in evaluating for uterine dehiscence because of poor correlation between imaging findings and clinical-surgical findings. They evaluated 54 women with post–cesarean delivery antibiotic-resistant puerperal infections, five of whom had surgically proved uterine dehiscence. Only two of these women had evidence of dehiscence at CT. Five other women had CT evidence of uterine dehiscence but no clinical evidence; two of these five women had negative laparotomy findings (16). The presence of a bladder flap hematoma greater than 5 cm and larger pelvic hematomas should be considered abnormal and highly suspicious for uterine dehiscence in the proper clinical setting (17). MR imaging may be better than CT in evaluating for uterine dehiscence because of its multiplanar capability and greater soft-tissue contrast (and, thus, its ability to help identify an intact serosal layer) (Fig 11). In a study by Maldjian et al (17), MR imaging yielded the best results in delineating an intact serosal layer in patients with uterine dehiscence and was, therefore, more likely to help differentiate uterine rupture from dehiscence. Using CT and multiplanar reformatted sequences, we have found CT to be a good initial imaging modality, especially using the reformatted images that are perpendicular to the plane of incision, most commonly the sagittal images. Although dehiscence can be treated conservatively with antibiotics, complete rupture usually requires surgical intervention.



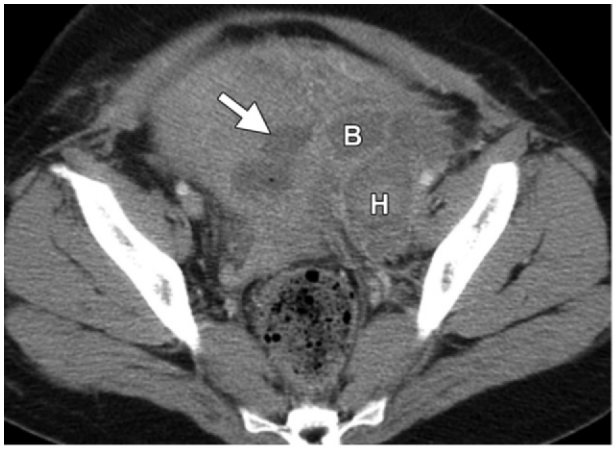
a. b.

Figure 10. Superficial wound dehiscence and left rectus muscle hematoma in a 22-year-old woman who had undergone emergent cesarean delivery and presented with postoperative fever that was unresponsive to antibiotics. **(a)** Axial contrast-enhanced CT scan reveals dehiscence of the skin incision (arrow) with subcutaneous gas and fluid (arrowheads). **(b)** Axial contrast-enhanced CT scan demonstrates a small hematoma (arrow) in the left rectus muscle. At the time of surgery, the incision had to be extended further laterally into the rectus muscle.

Figure 11. Uterine dehiscence in a patient who had recently undergone cesarean delivery. The patient was treated conservatively. Sagittal fat-saturated T2-weighted MR image demonstrates a large (>5-cm) intermediate- to high-signal-intensity hematoma (arrow) at the lower uterine incision site that communicates with the endometrium. The uterine serosa (arrowhead) is intact. The size of the hematoma and its continuity with the endometrium strongly suggest dehiscence. (Courtesy of James Ruiz, MD, Woman's Hospital, Baton Rouge, La.)

Uterine Rupture

Uterine rupture is the most severe potential complication of cesarean delivery and is defined as separation of all layers of the uterine wall, including the serosal layer, with abnormal communication between the uterine cavity and the peritoneal cavity (10). The presence of gas within the uterine defect extending from the endometrial cavity to the extrauterine parametrium in association with hemoperitoneum increases the likelihood of rupture in the appropriate clinical setting (10). Although a simple bladder flap hematoma greater than 5 cm should alert the radiologist to the possibility of uterine dehiscence, a larger amount of blood or an infection in the myometrium that extends into an infected bladder flap hematoma or parametrial abscess should raise greater concern for uterine rupture, especially if direct communication with the endometrium can be visualized (Figs 12, 13) (17). Nonetheless, given the infrequency of these complications and the lack of standardized imaging criteria for diagnosis, the radiologist could suggest uterine dehiscence or rupture in the report. However, because of the poor correlation between radiologic and surgical findings in uterine dehiscence or rupture, further management of the patient must take into account the patient's clinical status.



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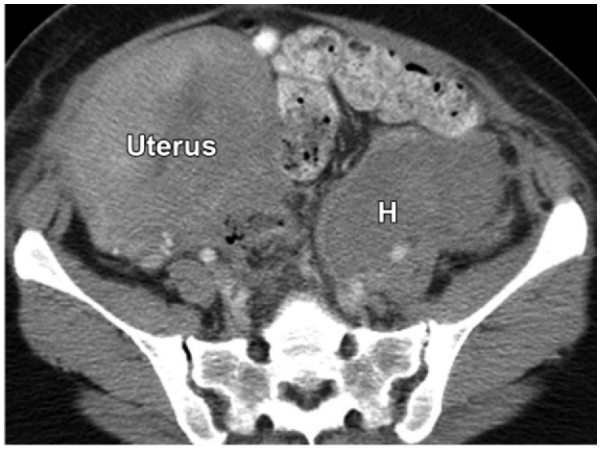

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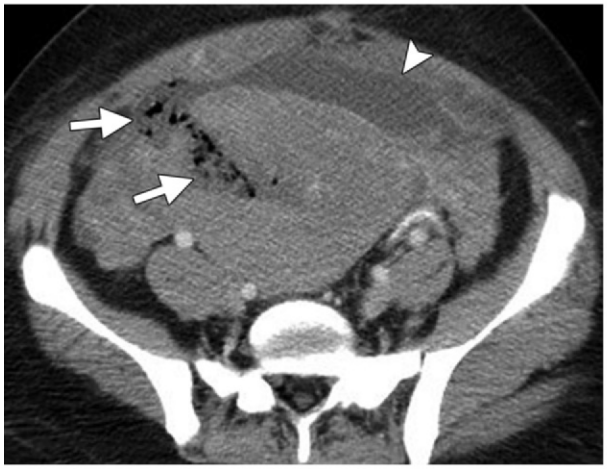

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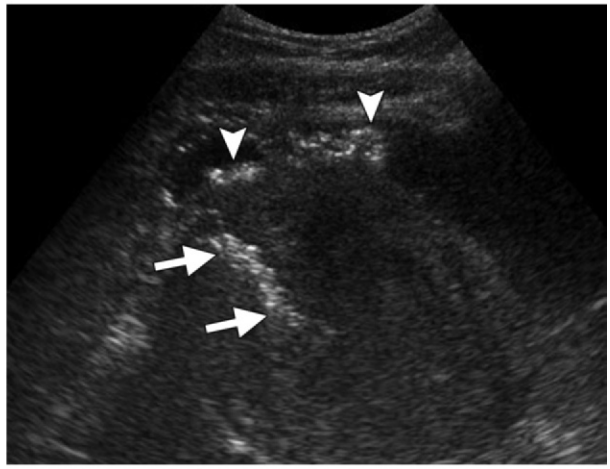


13b.

Figures 12, 13. **(12)** Uterine rupture in a 33-year-old woman who presented with abdominal pain 2 days after undergoing emergent cesarean delivery. **(a)** Axial contrast-enhanced CT scan demonstrates extra- and retroperitoneal hematomas *(H)* that are contiguous with the uterine incision site (arrow). *B* = broad ligament. **(b)** Axial contrast-enhanced CT scan obtained at a higher level shows the left-sided hematoma *(H)*. **(13)** Endometritis proceeding to uterine rupture in a 35-year-old woman who had recently undergone emergent cesarean delivery for premature rupture of membranes and chorioamnionitis. The patient was treated conservatively with catheter drainage. **(a)** Axial contrast-enhanced CT scan demonstrates complex gas-containing fluid (arrows) extending from the endometrium, through the uterine wall, and out into the peritoneum. There is also complex fluid anterior to the uterus (arrowhead), a finding that is in keeping with an infected bladder flap hematoma. **(b)** Transverse transabdominal US image of the pelvis obtained the same day reveals hyperechoic foci (arrows) representing gas within the uterine incision, extending through the uterine wall and anteriorly into an infected gas-containing bladder flap hematoma (arrowheads).

Ovarian and Pelvic Septic Thrombophlebitis

Ovarian and pelvic septic thrombophlebitis is reported to occur in one out of every 600 deliveries, but this prevalence is likely underestimated. It is usually unilateral, occurring more frequently on the right side than on the left. Thrombus in the right ovarian vein can extend all the way to the inferior vena cava. CT and MR imaging are the imaging modalities of choice, since US is often limited by overlying bowel gas in these patients. Imaging findings include enlarged ovarian or other pelvic veins with low-density thrombus in the center of the lumen, surrounded by an enhancing vessel wall and adjacent inflammatory stranding (Fig 14).

Chronic Complications after Cesarean Delivery

Adhesions

As with other surgeries, postoperative adhesions are a well-known complication of cesarean delivery and have an impact on maternal and fetal health by causing bowel obstruction, chronic

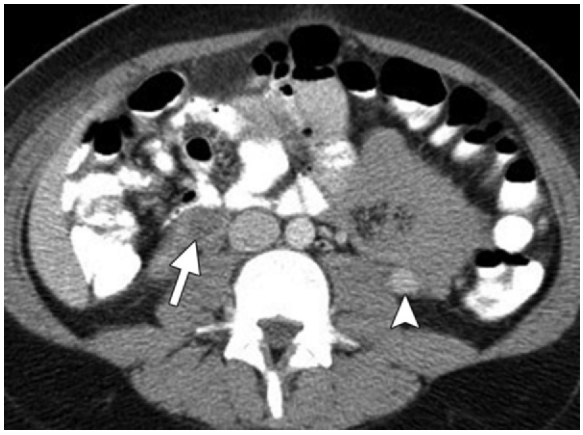
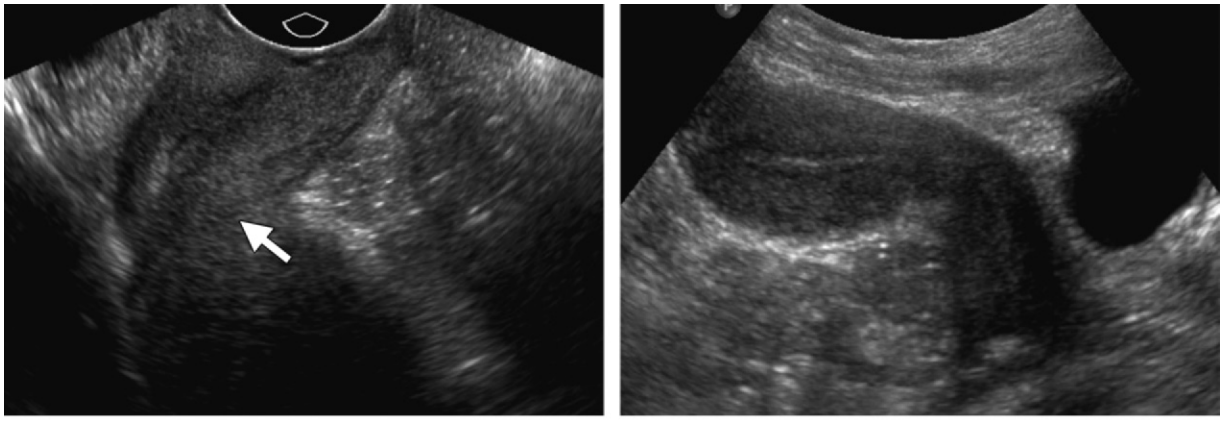


Figure 14. Septic thrombophlebitis of the right ovarian vein in a 36-year-old woman who had recently undergone cesarean delivery. The patient had a history of chorioamnionitis and failure to progress at 41 weeks gestation. Axial contrast-enhanced CT scan demonstrates a dilated right ovarian vein with central low-attenuation thrombus and a hyperenhancing wall (arrow). Note the normally enhancing left ovarian vein (arrowhead).



a. b.

Figure 15. Limited visualization of the uterus in a patient who had undergone her first and only cesarean delivery 2 years earlier. **(a)** Sagittal transvaginal US image clearly depicts the cervix (arrow) and lower uterine segment but not the uterus. **(b)** Sagittal transabdominal US image depicts the entire uterus. The anteverted, mildly retroflexed post–cesarean delivery uterus is better seen transabdominally than endovaginally because of its elongation and anterior position, which are caused by adhesions tethering the lower uterine segment to the anterior abdominal wall.

pain, infertility, and subsequent birth issues (eg, delay in newborn extraction or injury to the maternal bowel or bladder during subsequent surgeries). Adhesions are commonly seen after primary cesarean delivery (reported prevalence of 46%–65%), with increased frequency and severity at subsequent cesarean deliveries (18,19).

Because the orientation of the uterus can be affected by the development of adhesions, awareness of prior cesarean deliveries is crucial when imaging the pelvis. After cesarean delivery, the uterus frequently assumes an anteverted retroflexed position because of adhesions tethering the lower uterine segment to the anterior abdominal wall at the site of the incision. The adhesions elongate the cervix or lower uterine body, thereby displacing the uterus out of the pelvis. Consequently, much of the uterus is located beyond the range of the high-frequency endovaginal transducer, which provides images of only the cervix and the lower uterine segment, creating a potential US technical pitfall in inexperienced hands (Fig 15). Transabdominal US is preferred for evaluating the post–cesarean delivery uterus with this configuration because of the anterior location of the uterus and the decreased distance from the transducer. Although bladder distention is usually encouraged for transabdominal pelvic US, it is discouraged in patients with this typical postoperative uterine configuration, since a distended bladder may further displace the uterine body and fundus out of the pelvis (Fig 16). Thus, the post–cesarean delivery uterus should initially be evaluated transabdominally to assess uterine orientation, since endovaginal examination may be quite limited in some of these patients (20).

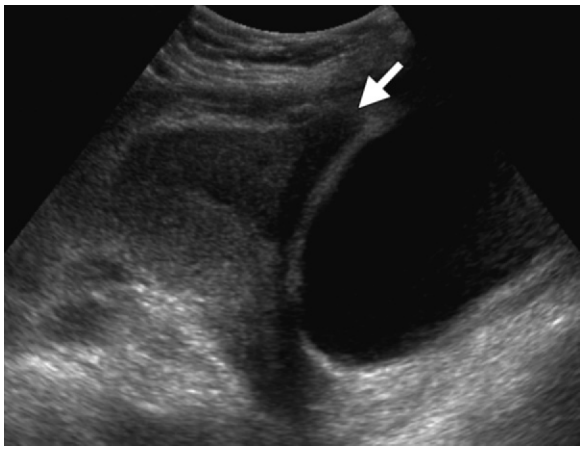


Figure 16. Further elongation of the lower uterine segment by a distended bladder in a post–cesarean delivery uterus. Sagittal transabdominal US image reveals tethering of the anterior uterine body to the anterior abdominal wall (arrow), with displacement and marked elongation of the lower uterine body by the distended bladder.

Figure 17. Anterior uterine deformity in a patient with a history of two cesarean deliveries. Sagittal T2-weighted MR image of the uterus demonstrates myometrial thinning in the anterior lower uterine segment (arrow), which, together with the bulbous superior myometrium, creates an hourglass configuration. The high-signal-intensity endometrium is puckered into the scar.

Healed Cesarean Scar

A healed cesarean scar appears as a narrow transverse line in the anterior lower uterine segment. At the level of the scar, thinning and retraction of the anterior myometrium create wedge-shaped defects, frequently on both the serosal and endometrial sides. This distortion and prominence of the tissues adjacent to the scar often have an "hourglass" shape on sagittal views (Fig 17). Thus, whether US, CT, or MR imaging is being used, cesarean scars are best identified on sagittal images. Armstrong et al (21) showed that endovaginal US is 100% sensitive and specific for the detection of cesarean delivery scars. At US, the chronic cesarean scar site appears as a narrow hypo- or hyperechoic line in the thinned anterior lower uterine segment (Fig 18) (21). A similar configuration is seen at CT and MR imaging, except that the myometrial portion of the thin, transversely oriented scar is iso- to mildly hypoattenuating at CT and hypointense at T1- and T2-weighted MR imaging. At MR imaging, the chronic low-signal-intensity appearance of the scar is seen as early as 3 months after surgery, whereas the normal zonal anatomy of the uterus reappears after 6 months (22). Occasionally, focal areas of very low signal intensity are noted in the scar region on T1-weighted and gradient-echo MR images, likely representing susceptibility artifact from surgical material or hemosiderin deposition. The tissue superior to the scar commonly assumes a rounded configuration that may be related to differences in muscle contraction and often becomes more pronounced with increasing numbers of cesarean deliveries (23). At US, this bulbous superior myometrium is occasionally mistaken for a fibroid, since the myometrium may appear hypoechoic and, because of its rounded configuration, casts shadowing edge artifact (Fig 19).

Cesarean Scar Niche.—In some women, there is tethering of the endometrium in the region of the old cesarean scar, creating a potential reservoir or "niche" that accumulates fluid or blood (Fig 20). Because of either poor contractility of the muscle adjacent to the scar or fibrotic tissue impeding the drainage of blood through the cervix, blood may persist in the niche after menstruation (23,24). Histologic evaluation of

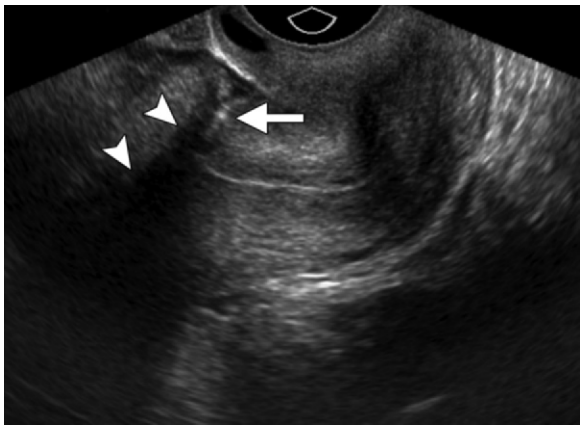


Figure 18. Normal cesarean delivery scar in a patient with a history of one cesarean delivery. Sagittal transvaginal US image of the lower uterine segment reveals a thin echogenic line (arrow) representing the old incision, with anterior myometrial thinning and adjacent shadowing edge artifact (arrowheads).

Figure 19. Normal cesarean delivery scar. Sagittal transvaginal US image of the uterus demonstrates hypoechoic myometrium (arrowhead) superior to the cesarean scar, a frequently encountered finding that is occasionally mistaken for a fibroid. Shadowing edge artifacts and a small amount of fluid in the endometrial canal at the level of the scar are also noted.

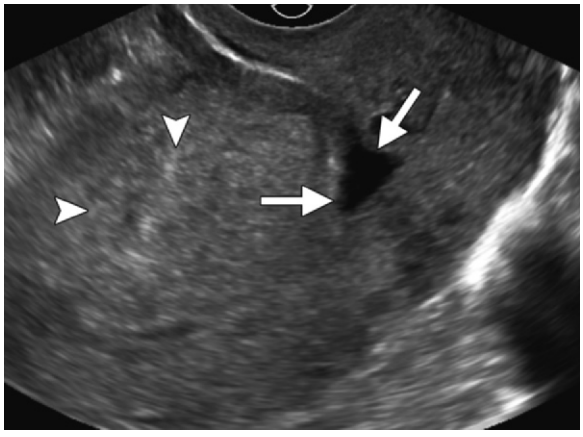


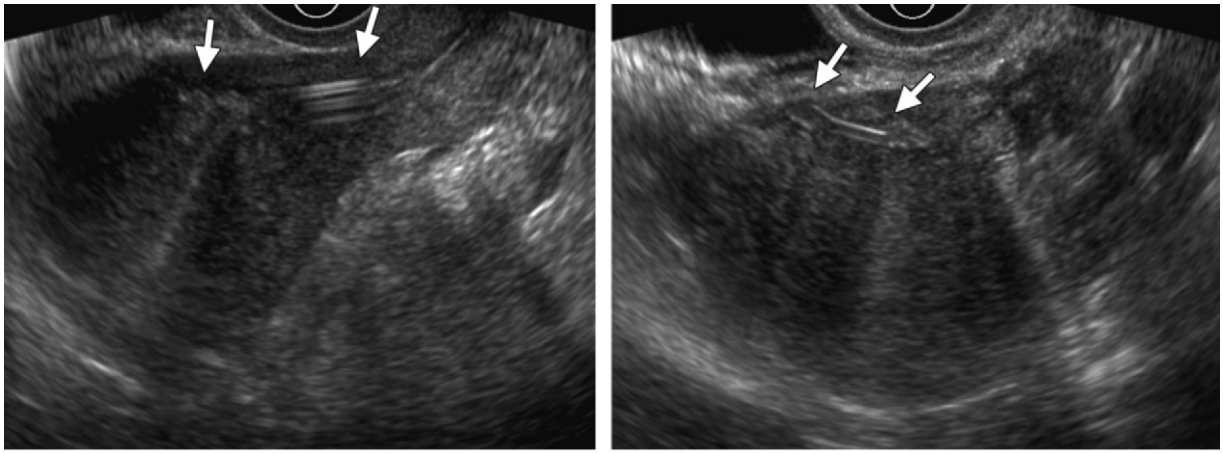
Figure 20. Fluid-filled cesarean scar niche in a patient with a history of two cesarean deliveries. Sagittal transvaginal US image demonstrates a triangular fluid-filled niche (arrows). Arrowheads = adenomyosis of the anterior uterine body.

the cesarean scar suggests that the congested inflamed endometrium in the superior edge of the scar may also serve as a source of bleeding (25). Blood that accumulates in this niche may serve as a source of dysfunctional uterine bleeding, accounting for spotting 2–12 days after the routine menstrual cycle. In a study by Bij de Vaate et al (24), postmenstrual spotting was reported in more than twice as many women with a niche (33.6%) as in those without (15.2%).

As expected, the myometrial defect at the scar is better appreciated at sonohysterography when it fills as the endometrial cavity distends with fluid or gel. In the study by Bij de Vaate et al (24), a niche was seen in 24% of patients at endovaginal imaging alone and in 56% of patients during intrauterine sonohysterography. Scar defects can have different shapes but are most commonly semicircular or triangular.

Patients with a history of multiple cesarean deliveries or who labored before cesarean delivery are more likely to develop one or more niches (21). In a study performed with saline-infused sonohysterography, there was no correlation between the number of cesarean deliveries and the depth of the niche (26). Although sonohysterography may be used to evaluate the niche, the relationship between the depth of the niche and the likelihood of uterine rupture during subsequent pregnancies has not yet been established (27). The differential diagnosis for simple fluid or blood in a cesarean niche includes nabothian cysts, prominent vessels, and small fibroids.

Malpositioned IUD.—US is the primary imaging modality used to evaluate the position of an IUD and associated complications. Regardless of shape, an IUD should be located between the internal os and the fundal region of the endometrial canal. At US, an IUD demonstrates variable echogenicity and posterior acoustic shadowing. A malpositioned IUD can cause pain, especially



a. b.

Figure 21. Malpositioned IUD in a cesarean scar. **(a)** Sagittal transvaginal US image demonstrates a low-lying IUD (arrows) in the lower uterine segment in the region of the cesarean scar. **(b)** Transverse transvaginal US image helps confirm that the right arm of the IUD (arrows) extends through the cesarean scar.

during intercourse, and is functionally less effective as a contraceptive. It may be located too low in the endometrial canal or partially in the cervix, penetrate the myometrium, or migrate into a uterine scar (as from prior cesarean deliveries) (Fig 21) (28). Although IUD position can be evaluated at two-dimensional imaging, three-dimensional (3D) US is helpful, especially when the ends of the IUD are in different planes. Peri et al (29) noted that in patients who had undergone previous cesarean deliveries, the lower end of the IUD may be located in the scar. The clinical significance of extension of the IUD into the cesarean scar—in particular, the risk of perforation—is uncertain.

Although CT is not used as the primary imaging modality to confirm IUD placement, IUDs are frequently seen at CT performed for other reasons. As in US, the location of the IUD should be evaluated with sagittal reformatted images in particular. Because of the ability of CT to better depict the entire uterus, the scar, and the adhesions, malpositioning of an IUD in the cesarean scar may be more easily appreciated with this modality.

Studies comparing the expulsion rates for IUDs placed immediately after placental delivery have described lower expulsion rates for IUDs placed through the cesarean hysterotomy than in women who had both a vaginal delivery and IUD insertion. The rate of complications (eg, pain, bleeding, infection, and perforation) is low, regardless of the timing or route of IUD insertion (30).

Abdominal Wall Endometriosis.—Abdominal wall endometriosis is a well-known complication of cesarean delivery that primarily affects women between 20 and 40 years of age. Endometriosis is defined as functioning endometrial tissue outside the uterine cavity (31). The most commonly accepted theory is that abdominal wall endometriosis associated with prior cesarean delivery is caused by iatrogenic seeding of endometrial cells from the hysterotomy. These ectopic endometrial cells respond to hormones, causing an inflammatory response in the adjacent tissues that may lead to a palpable mass and pain in the region of the cesarean scar. This pain is classically cyclic, occurring with the menstrual cycle, but it may be constant (31).

Abdominal wall endometrial implantation is estimated to occur in 0.03%–1% of patients who undergo cesarean delivery, but these figures may be low, since some patients are likely asymptomatic (31). On average, there is a 3.6-year delay between the inciting surgery and the development of symptoms from abdominal wall endometriosis. There is no increased association between abdominal wall endometriosis and intrapelvic endometriosis (32).

Because US is typically the initial imaging study in women with pelvic pain, abdominal wall endometriosis is most frequently diagnosed with this modality. Awareness of abdominal wall endometriosis is important because the anterior abdominal wall is not typically evaluated during

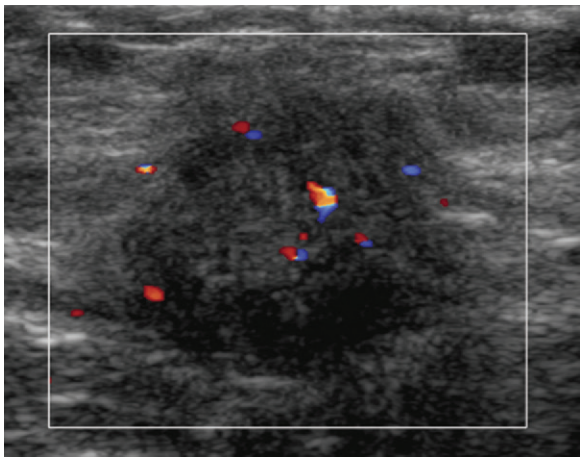
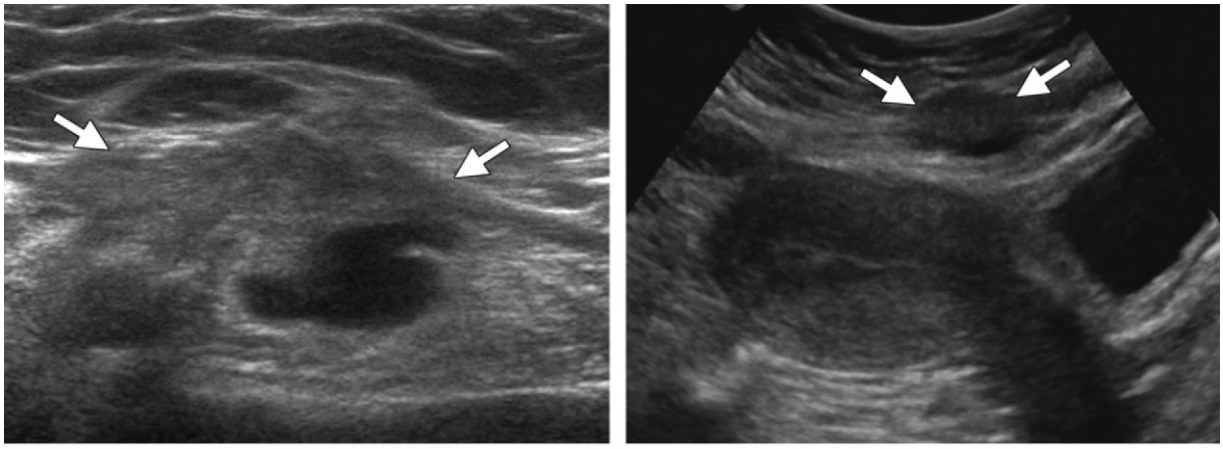


Figure 22. Abdominal wall endometrial implant in a woman with a history of one cesarean delivery and 4 months of left-sided pelvic pain. Transverse color Doppler US image obtained with a 12–5-MHz transducer over the area of pain in the left pelvic wall reveals a round hypoechoic mass with flow in the abdominal wall musculature.



a. b.

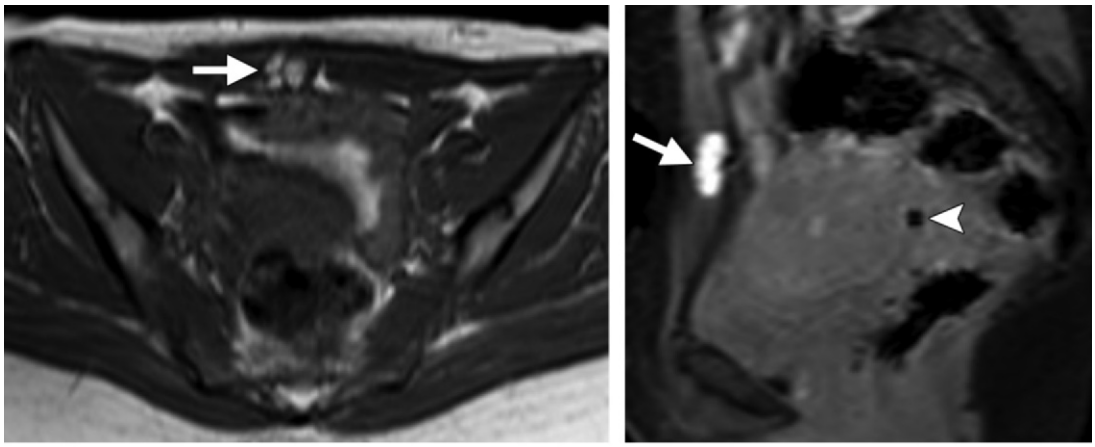
Figure 23. Abdominal wall endometrial implant with focal blood pooling in a patient with a history of two cesarean deliveries and superficial left-sided pelvic pain at the cesarean scar. **(a)** Transverse US image obtained with a 12–5-MHz linear transducer reveals an ill-defined mass (arrows) in the fascia and underlying musculature. The mass contains soft-tissue and fluid components from pooling blood and adjacent inflammation. **(b)** Sagittal transabdominal US image shows an abdominal wall endometrial implant (arrows), which was initially overlooked with the curved 5–1-MHz transducer. Note the anteverted retroflexed uterus with lower uterine segment deformity from a prior cesarean delivery scar.

Teaching Point

routine pelvic US. This highlights the importance of querying patients regarding their symptoms, and if a patient complains of superficial pain or a mass, an appropriate high-frequency linear transducer should be used (20). Neither the lower-frequency transducers used for routine transabdominal imaging nor high-frequency transvaginal probes are optimal for visualizing the superficial abdominal wall.

At US, endometrial implants in the abdominal wall are typically round or oval, heterogeneous but primarily hypoechoic solid lesions found in the subcutaneous fat, muscle, or fascial layers (Fig 22). The larger the lesion, the more irregular the margin and the more vascularity that is demonstrated at color Doppler imaging. Small cystic areas (when present) represent blood pooling from recent hemorrhage (Fig 23) (33). Increased echogenicity in the surrounding tissues results from the inflammatory effects of the blood products.

Although a combination of patient history, physical examination findings, and typical US findings is usually sufficient for the diagnosis of abdominal wall endometriosis, CT or MR imaging may be performed to assess the extent of disease, with MR imaging being preferred because of its superior soft-tissue contrast. At CT, abdominal wall endometriosis appears as a solid enhancing mass, typically with an attenuation similar to that of muscle, and associated with variable adjacent inflammatory changes. At MR imaging, a typical lesion contains areas of T1 hyperintensity from subacute blood products (Fig 24), which helps differentiate abdominal wall endometriosis from other abdominal wall masses, including



a. b.

Figure 24. Abdominal wall endometrial implant in a 40-year-old woman with a distant history of cesarean delivery and several years of painful menstrual periods. **(a)** Axial T1-weighted MR image reveals focal areas of increased signal intensity (arrow) in the medial right rectus muscle representing subacute blood from hormonally stimulated ectopic endometrial tissue in the abdominal wall. **(b)** Sagittal fat-saturated T1-weighted MR image helps confirm the presence of a high-signal-intensity endometrial implant (arrow) in the abdominal wall. A focal area of low signal intensity (arrowhead) is incidentally noted in the anterior lower uterine segment, a finding that likely represents susceptibility artifact from surgery.

postsurgical fibrosis, desmoid tumor, metastases, sarcoma, and lymphoma (12). Imaging is also helpful in differentiating abdominal wall endometriosis from other entities with similar symptoms, including ventral hernia, abscess, lipoma, and sebaceous cyst (33).

If necessary, the diagnosis can be confirmed with fine needle aspiration, showing endometrial stroma and glands in abdominal wall muscle with inflammatory cells and surrounding fibrosis. Endometrial implants are treated with wide surgical excision, with reported recurrence rates of 4.3% (32). Although rare cases of malignant transformation have been documented, there is no recommendation for follow-up imaging. Thorough cleaning of the abdominal wound with high-jet irrigation may help decrease the prevalence of abdominal wall endometrial implantation (32,33).

Ectopic Pregnancy and RPOC at the Cesarean Scar.—Implantation of the embryo in a cesarean delivery scar is the rarest form of ectopic pregnancy but is a life-threatening condition due to the high risk of uterine rupture (34). The reported prevalence in women with prior cesarean delivery is 0.15% (35). The absolute prevalence may be higher but unappreciated at imaging or even at surgery. The pretreatment diagnosis is being made more frequently due to increased use of transvaginal US and increased awareness of the condition (36). The diagnosis is most often made in the first trimester, and, in one series, the gestational age at diagnosis ranged from 5 weeks 0 days to 12 weeks 4 days (35). It is unclear whether the risk is related to the number of prior cesarean deliveries. In a review of 112 cases of cesarean scar ectopic pregnancies, 52% occurred with only one prior cesarean delivery (37). The most common presenting symptom was painless vaginal bleeding (39% of cases); 16% of women had accompanying mild to moderate pelvic pain, 9% had only abdominal pain, and 37% were asymptomatic (37). Severe acute pain with profuse vaginal bleeding implies impending rupture (38). The exact cause of cesarean scar ectopic pregnancy is unknown, but any process that disrupts or scars the endometrium and myometrium can predispose to abnormal pregnancy implantation (34). Other surgeries that increase risk for an intramural pregnancy include curettage, myomectomy, metroplasty, and hysteroscopy (34). The trophoblast likely invades the myometrium through a tract created by surgery. It is unclear whether scars with large niches predispose to ectopic implantation (39). Incomplete healing of the scar may predispose to scar implantation, since there are several reports of occurrence within months of cesarean delivery. In one series, however, the time interval from the last cesarean delivery to the diagnosis of cesarean scar ectopic pregnancy ranged from 6 months to 12 years (35).

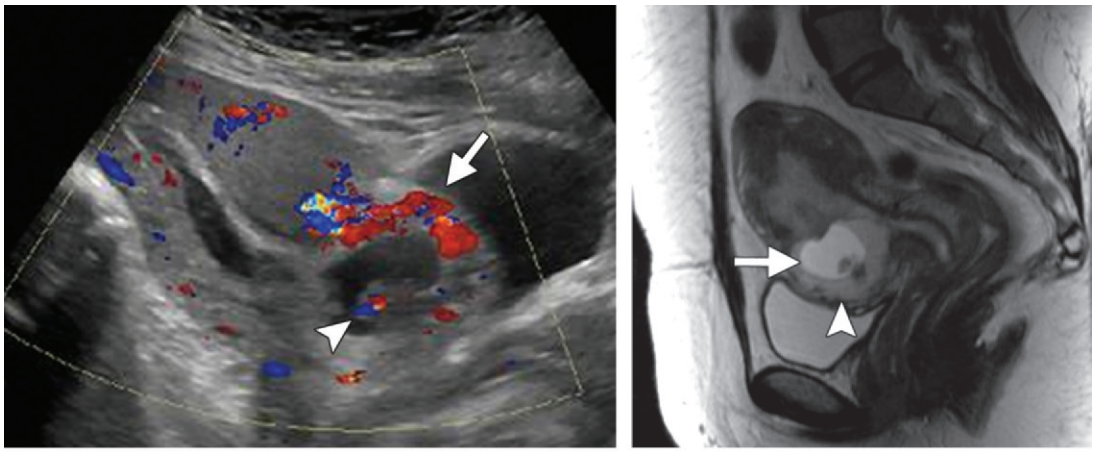


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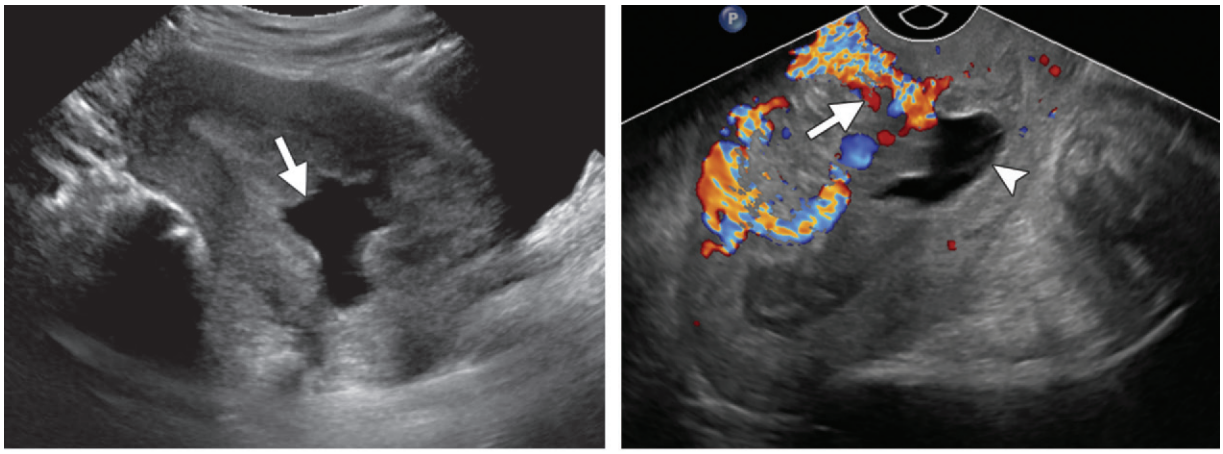
Figure 25. Cesarean scar ectopic pregnancy in a patient who had undergone cesarean delivery 7 years earlier. The patient presented with light vaginal spotting and no pelvic pain. **(a)** Sagittal transabdominal color Doppler US image of the uterus demonstrates a gestational sac with a live embryo at 8 weeks 2 days gestation (arrowhead) in the cesarean scar. Trophoblastic flow (arrow) is seen between the sac and the urinary bladder. **(b)** Sagittal T2-weighted MR image clearly shows the gestational sac (arrow) implanted at the cesarean scar, with significant anterior myometrial thinning (arrowhead). (Fig 25 courtesy of Lisa Jones, MD, PhD, Hospital of the University of Pennsylvania, Philadelphia, Pa.)

Transvaginal US is the first imaging modality used—and often the only one necessary—to diagnose cesarean scar ectopic pregnancy, with a reported sensitivity of 86.4% in one study (37). Several transvaginal US criteria have been described. On a sagittal view of the uterus at the level of the gestational sac, there should be a discontinuity in the anterior uterine wall representing the cesarean delivery scar (40). The uterine-cervical cavity is empty, and the gestational sac is located predominantly in the lower uterine segment myometrium between the bladder and the anterior uterine wall. The overlying myometrial thickness can be quite thin; in one series, it was less than 5 mm in two-thirds of cases and measured as little as 2 mm (41). In our experience, the gestational sac at the scar can range from complete invagination into the scar surrounded by myometrium, to the other extreme, in which the sac adheres to the scar abutting the endometrium. These findings are supported by Vial et al (42), who described two different types of pregnancies in the cesarean delivery scar. The first type is implantation on the scar with growth of the sac into the cervicoisthmic space and uterine cavity. The second type is a deep implantation in a cesarean delivery scar defect with progression outward toward rupture. Color and pulsed Doppler US are crucial for diagnosis and will show low-resistance arterial peritrophoblastic flow, mainly between the bladder and the anterior uterine wall (Fig 25a) (40,43). Three-dimensional gray-scale and 3D power Doppler US can show subtle abnormalities of the uterine contour and depict the abnormal vascularity, thereby increasing diagnostic confidence (44). Transabdominal images obtained in patients with a full bladder may help by providing a panoramic view, showing the relationship of the sac to the urinary bladder (39). MR imaging may be reserved for difficult cases, and sagittal T2-weighted images will show the gestational sac embedded in the myometrium of the anterior cervix–lower uterine segment (Fig 25b). In our experience, the likelihood that this diagnosis is suggested depends on the size of the gestational sac and how unusual the location appears. Although we typically avoid using color and pulsed Doppler US in early gestations, if cesarean scar ectopic pregnancy is being considered, Doppler US can be extremely helpful in confirming the abnormal implantation site.

Teaching Point

Teaching Point

The differential diagnosis for a gestational sac in the lower uterine segment–cervix in a patient with prior cesarean delivery consists of cesarean scar ectopic pregnancy, spontaneous abortion in progress, and cervical ectopic pregnancy (34). Cases of spontaneous abortion in progress usually show no trophoblastic flow adjacent to the gestational sac, since the sac has detached from the implantation site. The gestational sac may be irregular, will be located in the endometrial-endocervical canal, and will be shown at follow-up imaging to have passed out of the uterus. Clinically,



a. b.

Figure 26. RPOC at the cesarean scar in a 22-year-old woman with a remote history of cesarean delivery. The patient presented with heavy vaginal bleeding and pelvic cramping. **(a)** Sagittal transabdominal US image of the uterus demonstrates an irregular saclike structure (arrow) in the region of the lower uterine segment. **(b)** Sagittal transvaginal color Doppler US image demonstrates prominent trophoblastic flow (arrow) in the anterior lower uterine myometrium, a finding that confirms implantation at the cesarean delivery scar. Note the irregular saclike structure (arrowhead) in the region of the lower uterine segment. Spectral Doppler US showed low-resistance high-velocity arterial flow.

in spontaneous abortion the volume of bleeding is greater, and there is also pelvic cramping and pain (35). A cervical ectopic pregnancy is located in the endocervical canal rather than the myometrium adjacent to the cesarean delivery scar (34). There should be a normal layer of myometrium between the embryo and the urinary bladder, and the uterus can have an hourglass shape (45). Color Doppler US will show trophoblastic flow adjacent to the gestational sac. Follow-up US will show a persistent gestational sac in the cervix, although as the pregnancy progresses it may become more difficult to make an accurate diagnosis.

Complications of cesarean scar ectopic pregnancy include uterine rupture and hemorrhage, which can occur early in the pregnancy, necessitating hysterectomy and occasionally resulting in death (35). Early diagnosis is crucial to preserve fertility and reduce mortality, since very few pregnancies will progress beyond the first trimester. Because this type of ectopic pregnancy is so rare, there are no specific guidelines for treatment, but the literature describes high success rates with the injection of methotrexate into the gestational sac and, occasionally, of potassium chloride into the fetal thorax using a transvaginal approach (34,38,40,43,46). Absorption of systemic methotrexate may be suboptimal because the gestational sac is surrounded by fibrous scar tissue rather than normal vascularized myometrium (39). Surgical management may involve delayed revision of the cesarean delivery scar after successful medical therapy, hysteroscopy and incision-aspiration of the ectopic mass with laparoscopy, or elective laparotomy and wedge excision of the gestational mass. Dilation and curettage should not be considered the therapy of choice because a majority of villi are implanted in the myometrium, thereby significantly increasing the risk of bleeding, uterine perforation, or damage to the urinary bladder (39).

RPOC can occur anywhere a pregnancy implants, including at a cesarean delivery scar. At two-dimensional US, RPOC has a variable appearance and can manifest as an irregular saclike remnant, an echogenic mass, or a mixed solid and cystic mass. However, the key to diagnosis is trophoblastic low-resistance high-velocity arterial flow on color and pulsed Doppler US images (Fig 26) (47).

Placenta Accreta.—Abnormal placentation, a complication that typically occurs later in pregnancy, is distinctly different from pregnancy implantation at the cesarean delivery scar. Placenta accreta most often occurs in the anterior lower uterine segment and is caused by a defect of the decidua basalis that allows varying invasion of the myometrium by chorionic villi. The two most important risk factors for placenta accreta are prior cesarean delivery and placenta previa. However, advancing maternal age (>35 years)

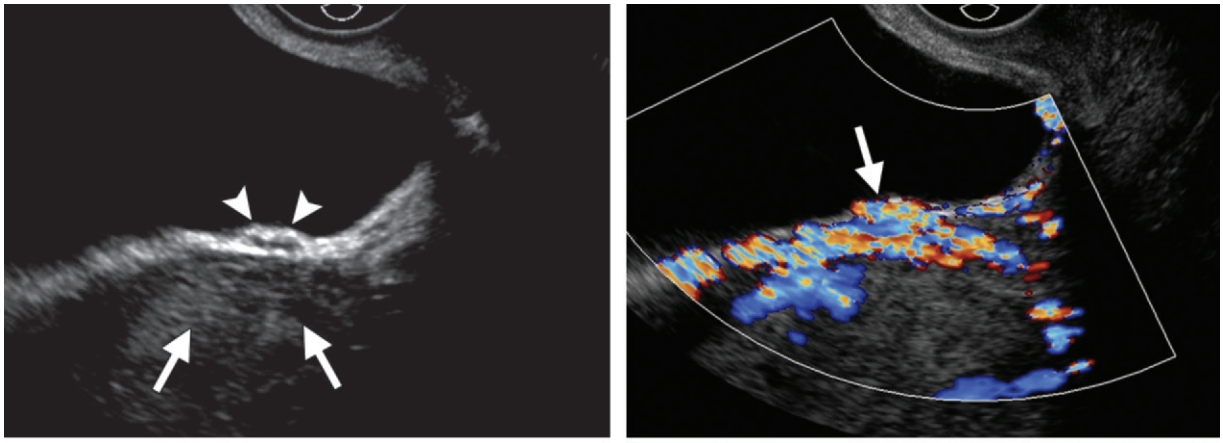


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Figure 27. Placenta percreta in a patient with a remote history of uterine surgery (myomectomy). **(a)** Transvaginal US image of the anterior lower uterine segment demonstrates irregularity of the posterior bladder wall (arrowheads) and an anterior placenta (arrows). **(b)** Sagittal color Doppler US image shows abnormal vascularity (arrow) located in the bladder serosa and arising from the anterior placenta. (Fig 27 courtesy of Sandra Allison, MD, Georgetown University Hospital, Washington, DC.)

and any previous myometrial disruption such as that caused by uterine surgery, instrumentation, or multiparity enhances trophoblastic adherence or invasion (48). In one series, the risk for gravid women with one prior cesarean delivery was increased more than twofold and was increased eightfold with two or more prior cesarean deliveries (49). When the placenta implants over the cesarean delivery scar, it is abnormally adherent 29%–40% of the time and can result in uncontrollable hemorrhage at delivery (48,50). Abnormal placental adhesion was the most common factor in uncontrolled postpartum hemorrhage necessitating emergent postpartum hysterectomy (51). Classification of abnormal placentation is based on depth of invasion. The mildest form is placenta accreta, in which there is implantation onto the uterine wall; placenta increta indicates deep myometrial invasion; and placenta percreta is characterized by extension through the serosa of the uterus.

Pregnant patients usually present for routine US between gestational weeks 18 and 20, at which time screening for abnormal placentation is performed. Transabdominal imaging can be followed with high-resolution transvaginal imaging if the position of the placenta (ie, anterior or low-lying) allows adequate visualization. Several series have shown US to have a sensitivity of 67%–86% and a specificity of 50%–93% in detecting placenta accreta (52–55). Described US imaging features of placenta accreta include loss of normal hypoechoic subplacental clear space, irregular placental vascular spaces representing lacunae, bulging of the uterine wall, and interruptions or bulging of the uterine serosa–bladder interface (52,56,57). The addition of color and power Doppler US may improve confidence and sensitivity; in most cases, however, the gray-scale findings are sufficient for diagnosis (53). Color and power Doppler US can show turbulent flow in placental lacunae, blood vessels surrounding the myometrium in cases of placenta increta, and hypervascularity in the bladder wall in cases of placenta percreta (Fig 27) (52,53,58). Baughman et al (57) describe an additional color Doppler US finding of a gap in the continuous retroplacental blood flow representing a region of placenta accreta.

MR imaging of placenta accreta has gained increasing attention and is most useful when US findings are inconclusive or there is a posterior placenta (53). MR imaging features of placenta accreta include a heterogeneous placenta, intraplacental T2-hypointense bands that may represent areas of fibrin deposition, bulging of the placenta in the lower uterine segment, and disorganized deep placental vascularity indicating abnormal vascular lacunae (59–61). Unfortunately, many of these findings can overlap with those of a normal placenta, making diagnosis difficult.

A summary of the imaging of acute and chronic complications following cesarean delivery is presented in Tables 1 and 2.

Table 1
Imaging of Acute Complications Following Cesarean Delivery

Acute Complication	Imaging Feature	Suggested Imaging Modality
Bladder flap hematoma	Collection between the urinary bladder and the lower uterine segment	Contrast-enhanced CT
Subfascial hematoma	Collection in the prevesical space posterior to the rectus muscles and anterior to the peritoneum	Contrast-enhanced CT
Uterine dehiscence	Incomplete rupture of the uterine wall with intact serosa	Contrast-enhanced CT (MR imaging in complicated cases)
Uterine rupture	Separation of all layers of the uterine wall with communication between the uterine cavity and the peritoneal cavity	Contrast-enhanced CT (MR imaging in complicated cases)

Table 2
Imaging of Chronic Complications Following Cesarean Delivery

Chronic Complication	Imaging Feature	Suggested Imaging Modality
Niche	Tethering of the endometrium, which can serve as a potential reservoir for intermenstrual blood and fluid	Transvaginal US, sonohysterography
Abdominal wall endometriosis	Endometrial implants in the subcutaneous fat, muscle, or fascia, typically with high signal intensity on T1-weighted MR images	US with a high-frequency linear transducer, MR imaging
Cesarean scar ectopic pregnancy, cesarean scar RPOC	Gestational sac and peritrophoblastic flow in the myometrium of the anterior lower uterine segment help differentiate this complication from an abortion in progress	Transvaginal US; transabdominal US provides larger field of view

Summary

Although it is an extremely safe procedure, cesarean delivery has a variety of acute complications. Because of the increasing frequency of this type of delivery, these unique complications are encountered more often by radiologists. During the immediate postsurgical period, CT is used most often, with US and MR imaging used on occasion. Familiarity with the appearance of normal postprocedural findings, including the myometrial defect and small hematomas in unusual locations (eg, bladder flap hematoma, subfascial hematoma), will allow the radiologist to identify significant complications, including major hematomas, uterine dehiscence, and rupture. Other general postpartum complications may be appreciated, including ovarian and general pelvic thrombophlebitis, RPOC, endometritis and myometritis, and a variety of wound infections. Unfortunately, there is significant overlap between normal postoperative gas collections and truly abnormal puerperal infections, including small amounts of air in the endometrial cavity and myometrial defect and in the superficial and deep layers of the abdominal wall.

At US, the delayed effects of cesarean delivery most commonly cause increasing technical difficulty in imaging the uterus, especially transvaginally because the scarred and tethered uterus is pulled out of the pelvis and can no longer be imaged with a high-frequency transducer. Subtle US issues include mistaking a scar for a myoma and development of a niche that acts as a reservoir for menstrual blood, with resulting menometrorrhagia. The cesarean scar can also serve as a site of endometriosis implantation, malpositioned IUD, and pregnancy implantation, resulting in both ectopic pregnancy and RPOC in this unusual location. Because the prevalence of abortion in progress is so much greater than that of cesarean scar ectopic pregnancy, the latter is easily overlooked, even by experienced radiologists, with serious consequences of bleeding and hysterectomy. Prior cesarean delivery also predisposes to abnormal

placental implantation, resulting in an increasing prevalence of placenta accreta. Predelivery diagnosis is often difficult but can be made with US or MR imaging. In summary, familiarity with the acute and chronic changes that can occur in the uterus after cesarean delivery will allow radiologists to make accurate diagnoses that are unique to this increasingly common surgical procedure.

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References

1. Betrán AP, Merialdi M, Lauer JA, et al. Rates of caesarean section: analysis of global, regional and national estimates. Paediatr Perinat Epidemiol 2007; 21(2):98–113.
2. Dresang LT, Leeman L. Cesarean delivery. Prim Care 2012;39(1):145–165.
3. Rebelo F, da Rocha CMM, Cortes TR, Dutra CL, Kac G. High cesarean prevalence in a national population-based study in Brazil: the role of private practice. Acta Obstet Gynecol Scand 2010;89(7): 903–908.
4. Nielsen TF, Hökegård KH. Postoperative cesarean section morbidity: a prospective study. Am J Obstet Gynecol 1983;146(8):911–916.
5. Hofmeyr JG, Novikova N, Mathai M, Shah A. Techniques for cesarean section. Am J Obstet Gynecol 2009;201(5):431–444.
6. Bates GW Jr, Shomento S. Adhesion prevention in patients with multiple cesarean deliveries. Am J Obstet Gynecol 2011;205(6 suppl):S19–S24.
7. Baker ME, Kay H, Mahony BS, Cooper CJ, Bowie JD. Sonography of the low transverse incision, cesarean section: a prospective study. J Ultrasound Med 1988;7(7):389–393.
8. Koutsougeras G, Karamanidis D, Chimonis G, et al. Evaluation during early puerperium of the low transverse incision after cesarean section through vaginal ultrasonography. Clin Exp Obstet Gynecol 2003;30(4):245–247.
9. Twickler DM, Setiawan AT, Harrell RS, Brown CE. CT appearance of the pelvis after cesarean section. AJR Am J Roentgenol 1991;156(3):523–526.
10. diFlorio-Alexander R, Harris RD. Postpartum complications. In: Fielding JR, Brown DL, Thurmond AS, eds. Gynecologic imaging. Philadelphia, Pa: Elsevier, 2011; 381–398.
11. Antonelli E, Morales MA, Dumps P, Boulvain M, Weil A. Sonographic detection of fluid collections and postoperative morbidity following cesarean section and hysterectomy. Ultrasound Obstet Gynecol 2004;23(4):388–392.
12. Paspulati RM, Dalal TA. Imaging of complications following gynecologic surgery. RadioGraphics 2010; 30(3):625–642.
13. Wiener MD, Bowie JD, Baker ME, Kay HH. Sonography of subfascial hematoma after cesarean delivery. AJR Am J Roentgenol 1987;148(5):907–910.
14. Auh YH, Rubenstein WA, Schneider M, Reckler JM, Whalen JP, Kazam E. Extraperitoneal paravesical spaces: CT delineation with US correlation. Radiology 1986;159(2):319–328.
15. Rivlin ME, Patel RB, Carroll CS, Morrison JC. Diagnostic imaging in uterine incisional necrosis/dehiscence complicating cesarean section. J Reprod Med 2005;50(12):928–932.
16. Brown CE, Dunn DH, Harrell R, Setiawan H, Cunningham FG. Computed tomography for evaluation of puerperal infections. Surg Gynecol Obstet 1991; 172(4):285–289.
17. Maldjian C, Milestone B, Schnall M, Smith R. MR appearance of uterine dehiscence in the post-cesarean section patient. J Comput Assist Tomogr 1998; 22(5):738–741.
18. Lyell DJ. Adhesions and perioperative complications of repeat cesarean delivery. Am J Obstet Gynecol 2011;205(6 suppl):S11–S18.
19. Morales KJ, Gordon MC, Bates GW Jr. Postcesarean delivery adhesions associated with delayed delivery of infant. Am J Obstet Gynecol 2007;196(5): 461.e1–e6.
20. Kirby CL, Horrow MM. Pitfalls in gynecological ultrasound. In: Fielding JR, Brown DL, Thurmond AS, eds. Gynecologic imaging. Philadelphia, Pa: Elsevier Saunders, 2011; 21–38.
21. Armstrong V, Hansen WF, Van Voorhis BJ, Syrop CH. Detection of cesarean scars by transvaginal ultrasound. Obstet Gynecol 2003;101(1):61–65.
22. Dicle O, Küçükler C, Pirnar T, Erata Y, Posaci C. Magnetic resonance imaging evaluation of incision healing after cesarean sections. Eur Radiol 1997;7 (1):31–34.
23. Thurmond AS, Harvey WJ, Smith SA. Cesarean section scar as a cause of abnormal vaginal bleeding: diagnosis by sonohysterography. J Ultrasound Med 1999;18(1):13–16.
24. Bij de Vaate AJ, Brölmann HA, van der Voet LF, van der Slikke JW, Veersema S, Huirne JA. Ultrasound evaluation of the cesarean scar: relation between a niche and postmenstrual spotting. Ultrasound Obstet Gynecol 2011;37(1):93–99.
25. Morris H. Surgical pathology of the lower uterine segment caesarean section scar: is the scar a source of clinical symptoms? Int J Gynecol Pathol 1995;14 (1):16–20.
26. Monteagudo A, Carreno C, Timor-Tritsch IE. Saline infusion sonohysterography in nonpregnant women with previous cesarean delivery: the "niche" in the scar. J Ultrasound Med 2001;20 (10):1105–1115.
27. Regnard C, Nosbusch M, Fellemans C, et al. Cesarean section scar evaluation by saline contrast sonohysterography. Ultrasound Obstet Gynecol 2004; 23(3):289–292.
28. Van Schoubroeck D, Van Den Bosch T, Mortelman P, Timmerman D. Sonographic determination of the position of a levonorgestrel intrauterine device. Ultrasound Obstet Gynecol 2009;33(1):121–124.

29. Peri N, Graham D, Levine D. Imaging of intrauterine contraceptive devices. J Ultrasound Med 2007; 26(10):1389–1401.
30. Kapp N, Curtis KM. Intrauterine device insertion during the postpartum period: a systematic review. Contraception 2009;80(4):327–336.
31. Hensen JH, Van Breda Vriesman AC, Puylaert JB. Abdominal wall endometriosis: clinical presentation and imaging features with emphasis on sonography. AJR Am J Roentgenol 2006;186(3):616–620.
32. Horton JD, Dezee KJ, Ahnfeldt EP, Wagner M. Abdominal wall endometriosis: a surgeon's perspective and review of 445 cases. Am J Surg 2008;196(2): 207–212.
33. Francica G, Giardiello C, Angelone G, Cristiano S, Finelli R, Tramontano G. Abdominal wall endometriomas near cesarean delivery scars: sonographic and color Doppler findings in a series of 12 patients. J Ultrasound Med 2003;22(10):1041–1047.
34. Fylstra DL. Ectopic pregnancy within a cesarean scar: a review. Obstet Gynecol Surv 2002;57(8): 537–543.
35. Seow KM, Huang LW, Lin YH, Lin MY, Tsai YL, Hwang JL. Cesarean scar pregnancy: issues in management. Ultrasound Obstet Gynecol 2004;23(3): 247–253.
36. Little EA, Moussavian B, Horrow MM. Cesarean delivery scar ectopic pregnancy. Ultrasound Q 2010; 26(2):107–109.
37. Rotas MA, Haberman S, Levgur M. Cesarean scar ectopic pregnancies: etiology, diagnosis, and management. Obstet Gynecol 2006;107(6):1373–1381.
38. Ash A, Smith A, Maxwell D. Caesarean scar pregnancy. BJOG 2007;114(3):253–263.
39. Maymon R, Halperin R, Mendlovic S, Schneider D, Herman A. Ectopic pregnancies in a caesarean scar: review of the medical approach to an iatrogenic complication. Hum Reprod Update 2004;10(6): 515–523.
40. Jurkovic D, Hillaby K, Woelfer B, Lawrence A, Salim R, Elson CJ. First-trimester diagnosis and management of pregnancies implanted into the lower uterine segment cesarean section scar. Ultrasound Obstet Gynecol 2003;21(3):220–227.
41. Weimin W, Wenqing L. Effect of early pregnancy on a previous lower segment cesarean section scar. Int J Gynaecol Obstet 2002;77(3):201–207.
42. Vial Y, Petignat P, Hohlfeld P. Pregnancy in a cesarean scar. Ultrasound Obstet Gynecol 2000;16(6): 592–593.
43. Pascual MA, Hereter L, Graupera B, Tresserra F, Fernandez-Cid M, Simon M. Three-dimensional power Doppler ultrasound diagnosis and conservative treatment of ectopic pregnancy in a cesarean section scar. Fertil Steril 2007;88(3):706.e5–e7.
44. Shih JC. Cesarean scar pregnancy: diagnosis with three-dimensional (3D) ultrasound and 3D power Doppler. Ultrasound Obstet Gynecol 2004;23(3): 306–307.
45. Ushakov FB, Elchalal U, Aceman PJ, Schenker JG. Cervical pregnancy: past and future. Obstet Gynecol Surv 1997;52(1):45–59.
46. Chiang AJ, La V, Chou CP, Wang PH, Yu KJ. Ectopic pregnancy in a cesarean section scar. Fertil Steril 2011;95(7):2388–2389.
47. Kamaya A, Petrovitch I, Chen B, Frederick CE, Jeffrey RB. Retained products of conception: spectrum of color Doppler findings. J Ultrasound Med 2009; 28(8):1031–1041.
48. Miller DA, Chollet JA, Goodwin TM. Clinical risk factors for placenta previa–placenta accreta. Am J Obstet Gynecol 1997;177(1):210–214.
49. Wu S, Kocherginsky M, Hibbard JU. Abnormal placentation: twenty-year analysis. Am J Obstet Gynecol 2005;192(5):1458–1461.
50. Zaideh SM, Abu-Heija AT, El-Jallad MF. Placenta praevia and accreta: analysis of a two-year experience. Gynecol Obstet Invest 1998;46(2):96–98.
51. Rossi AC, Lee RH, Chmait RH. Emergency postpartum hysterectomy for uncontrolled postpartum bleeding: a systematic review. Obstet Gynecol 2010; 115(3):637–644.
52. Finberg HJ, Williams JW. Placenta accreta: prospective sonographic diagnosis in patients with placenta previa and prior cesarean section. J Ultrasound Med 1992;11(7):333–343.
53. Levine D, Hulka CA, Ludmir J, Li W, Edelman RR. Placenta accreta: evaluation with color Doppler US, power Doppler US, and MR imaging. Radiology 1997;205(3):773–776.
54. Warshak CR, Eskander R, Hull AD, et al. Accuracy of ultrasonography and magnetic resonance imaging in the diagnosis of placenta accreta. Obstet Gynecol 2006;108(3 pt 1):573–581.
55. Lim PS, Greenberg M, Edelson MI, Bell KA, Edmonds PR, Mackey AM. Utility of ultrasound and MRI in prenatal diagnosis of placenta accreta: a pilot study. AJR Am J Roentgenol 2011;197(6): 1506–1513.
56. Comstock CH, Love JJ Jr, Bronsteen RA, et al. Sonographic detection of placenta accreta in the second and third trimesters of pregnancy. Am J Obstet Gynecol 2004;190(4):1135–1140.
57. Baughman WC, Corteville JE, Shah RR. Placenta accreta: spectrum of US and MR imaging findings. RadioGraphics 2008;28(7):1905–1916.
58. Lerner JP, Deane S, Timor-Tritsch IE. Characterization of placenta accreta using transvaginal sonography and color Doppler imaging. Ultrasound Obstet Gynecol 1995;5(3):198–201.
59. Lax A, Prince MR, Mennitt KW, Schwebach JR, Budorick NE. The value of specific MRI features in the evaluation of suspected placental invasion. Magn Reson Imaging 2007;25(1):87–93.
60. Derman AY, Nikac V, Haberman S, Zelenko N, Opsha O, Flyer M. MRI of placenta accreta: a new imaging perspective. AJR Am J Roentgenol 2011;197 (6):1514–1521.
61. Leyendecker JR, DuBose M, Hosseinzadeh K, et al. MRI of pregnancy-related issues: abnormal placentation. AJR Am J Roentgenol 2012;198(2):311–320.

Imaging after Cesarean Delivery: Acute and Chronic Complications

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It is important to be able to recognize and distinguish between subfascial and bladder flap hematomas because surgical evacuation of a bladder flap hematoma may require incision of the peritoneum, whereas a subfascial hematoma can be evacuated without opening the peritoneum (14).

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Uterine dehiscence is characterized by incomplete rupture of the uterine wall, usually involving the endometrium and myometrium but with an intact overlying serosal layer (10).

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This highlights the importance of querying patients regarding their symptoms, and if a patient complains of superficial pain or a mass, an appropriate high-frequency linear transducer should be used (20). Neither the lower-frequency transducers used for routine transabdominal imaging nor high-frequency transvaginal probes are optimal for visualizing the superficial abdominal wall.

Page 1707
The uterine-cervical cavity is empty, and the gestational sac is located predominantly in the lower uterine segment myometrium between the bladder and the anterior uterine wall.

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Color and pulsed Doppler US are crucial for diagnosis and will show low-resistance arterial peritrophoblastic flow, mainly between the bladder and the anterior uterine wall (Fig 25a) (40,43).