Multidetector CT appearance of the pelvis after cesarean delivery: normal and abnormal acute findings

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Cesarean section (CS) is the most frequent abdominal surgery performed in women. Its rate ranges from 3%–5% in Africa to 33% in the United States and 43.9% in Brazil with a reported worldwide global estimation of 15% (1). Complications such as hematomas, infection, abscesses, uterine dehiscence or rupture, pelvic thrombosis or thrombophlebitis may occur at an overall rate of 14.5%. Infection is the most common complication observed.

Ultrasonography (US) and multidetector computed tomography (CT) are frequently used to diagnose the most serious complications. During the first day after CS, it can be difficult to distinguish normal early postsurgical modification from possible uterine and pelvic complications. To date, only a few articles described the normal and acute abnormal CT findings of the female pelvis after CS (1–5). The aim of this article is to review the surgical technique of CS, and describe the expected normal and abnormal CT findings after CS as well as describe the most common acute complications. The additional role of MRI in the evaluation of normal and abnormal post-CS findings is also briefly described, in particular taking into account its added value in some specific settings.

Surgical technique

Cesarean delivery requires incision in the abdominal wall (laparotomy) and uterine wall (hysterotomy) (5). The most frequently performed surgical technique is the low transverse CS via a Pfannenstiel or Joel-Cohen skin incision (2–3 cm above the symphysis pubis); this type of uterine incision is usually recommended because it is related with less postoperative pain and blood loss, and it has the lowest risk for rupture in subsequent pregnancies (1, 5, 6). In this procedure, the fascia is opened and the rectus muscles are separated, followed by entrance into the peritoneum. A bladder flap may be generated by the incision of the loose reflection of the peritoneum that covers the uterus. Blunt dissection between the low uterine segment and bladder is performed and a low transverse incision is done in the myometrium.

Some surgical or obstetric indications may necessitate a classical (i.e., vertical) uterine incision in the body of the uterus; this type of incision is more susceptible to ruptures and can be associated with more complications both for the mother and the baby (1, 6). After delivery of the baby and the placenta, single- or double-layer suture is used to close myometrial
layers, followed by suture of the fascia and the skin.

Imaging

US and CT are often used to diagnose acute complications of CS. US is the first choice because it can be executed at bedside, does not require the use of ionizing radiation and is cost-effective. However, US is limited in demonstrating the real extent of some abnormalities, which require the use of second-level techniques (7).

CT is the modality of choice for imaging postsurgical or intra-abdominal complications, such as hematomas, abscesses, uterine dehiscence and rupture, and pelvic thrombophlebitis (1). Moreover, CT is usually employed to rule out active arterial bleeding in case of postpartum hemorrhage (5, 8). The reported protocols usually consist of three phases: an unenhanced scan (covering only the pelvis) followed by arterial phase (smart prep) and portal phase (80–90 s) scans extended to the whole abdomen or only to the pelvis for the arterial phase (5, 8). The unenhanced scans help to detect hematomas or free intra-abdominal fluid and to discriminate active bleeding from calcifications, metal clips, and hemostatic content (5). Contrast-enhanced arterial phase scans detect active bleeding and can be used to construct three-dimensional reformatted images of the vessels, which are very useful if embolization is planned. Portal phase scans help to differentiate active arterial bleeding from engorged vessels, active venous bleeding, and pseudoaneurysms (5). A selective acquisition of delayed phase scans (3–5 min) can be added to clarify confusing images (5). A significant amount of radiation could be required to perform the three-phase technique. To reduce the radiation exposure in young patients of childbearing age, alternative protocols such a two-phase CT technique (unenhanced and enhanced phases or two enhanced phases without the unenhanced phase) could be used. Moreover, restriction of the arterial and portal phase studies from below the liver to the inferior pubic ramus or low-dose scanning protocols could be used to reduce the total radiation dose (5). In order to avoid the unenhanced scan, we suggest the use of ultra-delayed acquisition (2–3 hours after intravenous contrast administration) in such cases of doubtful imaging findings.

However, to assess the clinical efficacy of these different protocols other future studies will be useful (5, 8). Multiplanar reconstructed and volume rendering imaging with oblique reconstruction provide added diagnostic capabilities; these postprocessing techniques demonstrate fine anatomic detail that would be difficult to achieve using axial reconstruction alone. Despite radiation hazard, CT is usually preferred to magnetic resonance imaging (MRI) because it is cost effective and quick. On rare occasions, MRI is performed to clarify doubtful US and CT findings or to study patients with contraindication to intravenous administration of iodine contrast material (8).

Compared with CT, MRI has the advantage of a greater intrinsic contrast resolution, which enables more precise evaluation of the zonal anatomy of the uterus and its relations to other organs and pelvic structures. This helps to define more precise location of any normal and abnormal postpartum alterations, and to clarify the extent of specific uterine wall lesions, such as uterine dehiscence or rupture. In addition, MRI is a technique that allows multiplanar acquisitions on the three traditional spatial planes (axial, sagittal, and coronal) as well as on planes oriented according to the longitudinal axis of the uterus (e.g., axial oblique).

MRI is generally performed using 1.5 T scanners and a phased array multi-coil. The protocol consists of axial T1- and T2-weighted sequences both with and without fat suppression obtained in the sagittal and axial planes. Axial images extend from the aortic bifurcation to pubis symphysis. Dynamic enhanced T1-weighted images are obtained after an intravenous bolus injection of gadolinium (8).

Normal acute findings of the postpartum

During the first days after CS, CT can be misinterpreted because some findings in the uterus may appear abnormal and mimic possible complications, but most of the times they are normal postsurgical appearance with no clinical significance (1, 8). The postpartum uterus is enlarged to twice its normal pre-pregnancy dimension (average size is 9x12x14 cm) (9). After delivery, the uterus shows a progressive involution from the gravid to the nongravid status, mainly during the first three days postpartum; the uterus progressively returns to its normal size within 6–11 weeks (5, 8). The postpartum endometrial cavity usually measures less than 2 cm (anteroposterior diameter) (4). Some fluid is commonly visible in the uterine cavity depicted as a hypodense area. Fresh blood clots are recognized by hyperdensity content within the endometrial cavity (Fig. 1) (5). Intrauterine fluid or blood debris should not be confused with infection or retained products of conception. Intracavitary gas, which is usually considered to be a sign of endometritis, may be found in asymptomatic women up to three weeks postpartum. Based on the literature, Hiller et al. (3) suggested that a small amount of gas in the endometrial cavity may be normal after CS, whereas abundant quantity of intrauterine gas, mainly at late postsurgical days, may suggest an infection.

The uterine and ovarian arteries are usually prominent in the postpartum period because blood flow increases during pregnancy. On contrast-enhanced CT, the uterine artery and its branches are visualized as tubular enhancing vessels in the parametrium. Intramural branches can be depicted as dot-like enhancing structures in the external part of the myometrium (Fig. 2) (5, 8). Increased vascularity of the myometrium may be a normal postpartum appearance in the ab-

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**Main points**

- Different acute complications may follow a cesarean section (CS), such as hematomas, infection, abscesses, uterine dehiscence or rupture, pelvic thrombosis or thrombophlebitis.
- Ultrasonography (US) and multidetector computed tomography (MDCT) are the most frequently used methods to detect the acute complications after CS.
- During the first day after CS, it may be difficult to distinguish normal early postsurgical changes from possible uterine complications, because there is a large variability in the MDCT aspect of the normal CS scar, and there is an important overlap between normal and abnormal postsurgical findings.
- MDCT findings such as the presence of myometrial interruption and small hematomas in unusual locations (bladder flap hematoma, subfacial hematoma) do not represent pathologically significant findings, whereas other conditions such as major hematomas, uterine dehiscence and rupture have to be identified as significant complications.
- Given the absence of standardized imaging findings for interpretation of uterine dehiscence and rupture, the radiologic suggestion of complications in the report must be evaluated in the appropriate clinical setting.
Acute pelvic complications following CS include same types of adverse events that occur after any surgery. The most frequent acute complications related to CS are infection, the low transverse incision presents ill-defined margins on axial CT images because it is parallel to the CT imaging plane. Sagittal and oblique axial reformatted CT images provide a better imaging of myometrial discontinuity by using imaging planes perpendicular and parallel to the surgical plane (5, 9). CT interpretation is often very difficult during the first days after CS, because normal early postsurgical changes and possible complications may have similar appearance (3). The myometrial discontinuity in the first postsurgical days in asymptomatic patients should not be read as possible complications such as uterine rupture or dehiscence (5, 9).

Moreover, Hiller et al. (3), in agreement with previous studies (2, 10, 11), did not find any correlations between postsurgical days and width of the surgical scar or between the CT finding of a full-thickness myometrial wall gap and the presence of a true myometrial defect. A full-thickness uterine interruption at the surgical site is likely due to edema with areas of compromised blood supply during the early postsurgical periods and a thick scar at later postsurgical reaction (3). In our opinion, when a full-thickness wall defect is recognized alone on CT without associated symptoms and signs and in the absence of other CT findings (collection or hematoma), true uterine dehiscence is unlikely. This concept is important, because it may prevent unnecessary surgery on the basis of CT findings alone.

The same postpartum changes that may be evaluated on CT, such as increased uterine dimensions, pelvic effusion, and blood in the uterine cavity may also be accurately visualized on US and MRI exams. Additional normal findings that MRI can show compared with US and CT in the postpartum period include high signal intensity on T2-weighted images of the parametria due to edema and in the outer cervical stroma related to prior unsuccessful trial of a normal spontaneous vaginal delivery. Also MRI shows the incision site of CS, which is visualized as increased signal intensity on T2-weighted images. Low signal intensity at the incision site on T2-weighted images, probably secondary to subacute hematoma, should not be confused with dehiscence (10).

Abnormal findings of the postpartum: acute complications

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Bladder flap hematoma may arise after CS done with a low uterine transverse incision, because the peritoneum is cut between the uterine wall and the bladder and returned inferiorly. Bleeding and dehiscence at the lower uterine surgical site may lead to hematoma formation in the potential extraperitoneal space between the bladder and the lower uterine segment (1, 5).

At first evaluation with US, bladder flap hematomas may be seen as a well-circumscribed hyperechoic fluid collection between the posterior wall of the bladder and the anterior wall of the lower uterine segment (1). At CT, the bladder flap hematoma is visualized as fluid collection (slightly hyperattenuating) between the posterior wall of the bladder and the anterior wall of the lower uterine segment. Generally bladder flap hematomas are small and can be interpreted as normal if the size is less than 4 cm on the axial plane (Fig. 4) (1). Hematomas larger than 5 cm are uncommon and have been associated with uterine dehiscence (5, 10).

Therefore the presence of a large bladder flap hematoma (more than 5 cm in size) should be considered carefully and should induce a more scrupulous search for dehiscence (Fig. 5) (10). Extravasation from the low uterine transverse incision is usually limited by the overlying peritoneum but

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**Figure 4. a, b.** Small bladder flap hematoma, in a 34-year-old woman with fever, pelvic pain and high white blood cell count, six days post-CS. Axial CT image (a) demonstrates the CS incision in the inferior uterine segment (arrows). A high-attenuation fluid collection (asterisks) with a small amount of gas is also present between the bladder and the uterus. No other pathologic findings were discovered. Sagittal reformatted CT image (b) better shows the relation of the small bladder flap hematoma (asterisk) to the surgical scar (arrow). The patient was successfully treated with antibiotic therapy.

**Figure 5. a, b.** Bladder flap hematoma in a 33-year-old woman with anemia, four days post-CS. Axial unenhanced CT image (a) and sagittal reformatted contrast-enhanced CT image in the venous phase (b) demonstrate a high-attenuation collection with fluid-fluid level due to fresh blood (arrowheads), located anterior to the uterus (U). A high attenuation free fluid component is also present posterior to the uterus (asterisk). Sagittal reformatted CT image (b) shows the position of the bladder flap hematoma located between the lower uterine part and the posterior bladder wall (arrowheads), adjacent to the CS incision (black arrow), and the fluid collection in the pouch of Douglas (asterisk). Rectus muscles enlargement is present (white arrow). A hypodense myoma is also present in the anterior uterine wall (O). The patient recovered after blood transfusions and antibiotic treatment.
Subfascial hematoma or rectus sheath hematoma

Subfascial hematoma or rectus sheath hematoma is an extraperitoneal hematoma expanding into the rectus sheath or into the prevesical space, adjacent to the rectus muscle and transversalis fascia but anterior to the peritoneum, in continuity with the space of Retzius (the inferior extent of the prevesical space) (1, 5, 12). Most of the extraperitoneal hemorrhages are the consequence of an injury to the inferior or epigastric vessels (arteries in particular) or their branches or a direct tear of the rectus muscle during CS. In fact, the inferior epigastric artery originates from the external iliac artery superior to the inguinal ligament and courses superomedially for a variable distance in the prevesical space before piercing the transversalis fascia and entering the posterior rectus sheath (12); it reaches the lower rectus abdominis and creates an anastomosis with the superior epigastric vessel (8). US demonstrates a cystic or complex collection deep in the rectus muscle and anterior to the bladder (13). Contrast-enhanced CT images show a hyperattenuating mass (70–90 HU) posterior to the rectus muscle or in the rectus sheath with ipsilateral muscle enlargement that can extend in the prevesical space and potentially cause hemoperitoneum (1, 5). Contrast-enhanced CT may also be helpful in detecting (or documenting) contrast material extravasation that represents active bleeding (1). Significant blood loss can result with subfascial hematoma, and up to 2500 mL of fluid may accumulate in this large space without manifestation of an evident abdominal-wall mass.

Active contrast extravasation outside the uterus on CT images can change the therapeutic decision, and selective arterial embolization is contemplated for those cases with no response to conservative approach (5, 8). Proper recognition of subfascial hematoma and its distinction from bladder flap hematoma is important because surgical drainage of a bladder flap hematoma requires incision of the peritoneum, while surgical evacuation of subfascial hematoma can be performed without this incision. More likely, subfascial hematoma and bladder flap hematoma coexist incidentally as common complications of CS (Fig. 7) (12). However,
these hematomas have different sources of bleeding (epigastric vs. uterine vessels) and should be treated as independent entities. Moreover, differentiating subfascial hematoma from superficial wound hematoma is also vital because of the possibility of major blood loss with subfascial hematoma (1, 12). The rectus muscle is a useful landmark for distinguishing these two different kinds of hematomas, with the superficial wound hematoma placed anterior to the muscle and the subfascial hematoma placed posterior to the rectus muscle. Subcutaneous fluid collection and gas are not infrequent findings, but areas of gas and fluid organized at the surgical site in the subcutaneous tissue may indicate extensive infection and abscess formation (Fig. 8) (1, 9). CT can also demonstrate complication of the skin as dehiscence of the site of the incision, with separation of the abdominal wall.

**Uterine dehiscence**

Uterine dehiscence or incomplete rupture of the uterus is characterized by an incomplete rupture of the uterine wall, commonly involving the endometrium and myometrium, with the overlying serosa maintaining its integrity (1). Uterine dehiscence is a very arduous CT diagnosis due to its overlap with the normal aspects of the CS. CT findings are nonspecific and there is a poor correlation with clinical-surgical findings, as previously demonstrated by some authors (3).

Incisional dehiscence and myometrial interruption can be recognized by a full-thickness transmyometrial gap with unclear margins at the site of incision (3). Free fluid, bladder flap hematoma, pleural effusion, bowel distension, and intrahepatic abscess are described as associated signs (1). The presence of a bladder flap hematoma larger than 5 cm or a big pelvic hematoma should raise suspicion for uterine dehiscence in the right clinical context (Fig. 9) (1). On the other hand, when a full-thickness myometrial wall gap is observed on CT, without other associated imaging features, such as collection or hematoma, and clinical symptoms, true uterine dehiscence is improbable (3). MRI is superior to CT for the diagnosis of uterine dehiscence; it has a higher sensitivity and specificity due to its multiplanar capability and greater soft-tissue contrast (1). MRI, particularly in the sagittal plane, can discriminate between uterine rupture and dehiscence by delineating all uterine wall layers and identifying an intact serosa covering the myometrial gap (10, 11, 14). On T2-weighted imaging, a normal CS scar will appear as a linear hyperintense focus in the myometrium, whereas a true dehiscence will appear as a hyperintense focus through the full thickness of the endometrium and myometrium, sparing the serosal layer. A small bladder flap hematoma can be present. Moreover, a true dehiscence is usually associated with a large hematoma or abscess that can be easily seen on MRI. Contrast-enhanced MRI is useful in confirming the thickness defect (14).

**Uterine rupture**

Uterine rupture occurs when all layers of the uterine wall are separated, including the serosal layer, with full thickness tear and

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**Figure 8. a, b.** Infected abdominal wall collections and pelvic abscess in a 33-year-old woman who presented with fever, pelvic pain, and high white blood cell count three days post-CS, with a CT diagnosis of subfascial hematoma (asterisks) that was surgically evacuated. The patients underwent a second CT four days later for persistence of fever and pelvic pain. Axial (a) and sagittal reformatted (b) images show persistence of bilateral rectus enlargement (asterisks) and prevesical fluid collection with rim enhancement (white arrows) due to infection. Note the position of the fluid collection, anterior to the bladder (B) and the uterus (U). Coexisting small subcutaneous gas-containing fluid collection in the anterior abdominal wall (arrowheads) was also depicted. The abdominal wall and pelvic collections were surgically drained with diagnosis of mycoplasma superimposed infection and the patient was subsequently treated with antibiotic therapy.

**Figure 9. a–c.** Uterine dehiscence in a 37-year-old woman with persistent fever and abdomino-pelvic pain three days post-CS. Axial CT images obtained at two different pelvic caudo-cranial levels (a, b) demonstrate an enlarged puerperal uterus with irregular CS incision in the anterior myometrial wall (black arrow) associated with a hyperattenuating gas-containing fluid collection (white arrow), anterior to the uterus. Posterior free fluid is also present (arrowhead). The endometrial cavity is expanded with fluid and air bubbles (asterisk). Sagittal reformatted plane (c) demonstrates a full-thickness transmural incision with loss of clear border of the myometrium (black arrow). Note the distended endometrial cavity with the presence of a myometrial inhomogeneity in the fundus at the site of the placental insertion (white arrow). Images and symptoms suggested uterine rupture or dehiscence and the patient was surgically treated. At surgery a uterine dehiscence at the right site of the CS was confirmed with associated right parametrial infected collection. Diffuse endometritis was also present.
This finding was surgically confirmed.

uterine fluid collection and fat stranding are also present gas-containing fluid pelvic collection

uterine rupture in the presence of a hematologist should be aware of the possibility of raises the probability of rupture in specific amount of blood in the peritoneal cavity within the uterine disrupted site spreading myometrium (1, 8, 15). The existence of gas attenuating defect inside the enhancingruption of the uterine wall looks like a hypooattenuating hematoma or parametrial abscess mainly if a direct link with endometrial cavity can be detected (1).

Ovarian and pelvic vein thrombosis and thrombophlebitis

Ovarian and pelvic vein thrombosis and thrombophlebitis occurs in one out of every 600 cesarean deliveries, but its prevalence is presumably underestimated (1). The period of onset can vary from 2 to 10 days postpartum. It is usually unilateral (only 10%–14% of cases are bilateral), affecting commonly the right ovarian vein (up to 80%–90%), likely because it is usually larger than the left one, has multiple incompetent valves (1, 4, 7, 9), and merges obliquely with the inferior vena cava. Moreover, the retrograde flow from the left renal vein to the ovarian vein during pregnancy and postpartum is thought to be protective (4). The thrombus from the right ovarian vein can spread anywhere in the inferior vena cava or renal vein (1, 9). A bland thrombus may be complicated by thrombophlebitis particularly in postpartum infection as endometritis. Clinical diagnosis may be difficult because patients usually present fever, acute pelvic and flank pain rather than specific symptoms (4, 15). Moreover, ovarian vein thrombosis can be difficult to discriminate from appendicitis in the postpartum female. The diagnosis is usually achieved on contrast-enhanced CT, but can be made with US, although US imaging is often limited by overlying bowel gas in these patients (1). Contrast-enhanced CT imaging findings of thrombosis include enlarged and tubular ovarian or other pelvic veins expanded by intraluminal low-density thrombus, surrounded by an enhancing vessel wall (Fig. 11). Looking in the direction of gonadal vein from the pelvis to the inferior vena cava or left renal vein may help discriminate it from the ureter, appendix, or inferior mesenteric vein. Perivascular adjacent inflammatory stranding with an expanded gonadal vein encourages the diagnosis of thrombophlebitis and differentiates it from bland thrombus (1, 4, 15). Moreover, thromboembolic complications can involve pulmonary embolism and deep vein thrombosis (4). Also the evaluation of ovarian vein patency can frequently be established with MRI noninvasively without the administration of intravenous contrast. For example, the absence of acute perivascular edema on T2-weighted images is an additional sign that can exclude acute deep venous thrombosis (11).

Uterine subinvolution: endometritis and retained products of conception

The physiologic reduction of the uterus to its normal size can be complicated by retained products of conception (RPOC), blood clots, or intrauterine infection or inflammation (5). The uterus will still look enlarged and demonstrate subinvolution. The retained placenta and decidua can act as a conduit for prolonged blood loss causing postpartum hemorrhage or as a nidus for infection. The principal causes of uterine subinvolution are infections (endometritis) and RPOC.

Endometritis is the principal cause of postpartum fever (1%–6% after cesarean delivery) (9, 15). Endometritis may proceed to myometritis, pelvic abscess, and septic thrombophlebitis (15). The symptoms of postpartum endometritis may vary from fever and abdominal pain to diffuse peritonitis and extreme uterine tenderness (7). CT is recommended for patients with no response to antibiotic therapy to evaluate uterine and extraterine complications (9). On contrast-enhanced CT, severe cases may show thickening of the uterine wall and the endometrial cavity because of the presence of fluid, or sometimes gas or debris; enhancement of the endometrium can be depicted (9, 15). Some amount of gas can also be present in normal postpartum uterus, particularly after instrumentation. Therefore, the diagnosis of endometritis...
cannot be made only on the base of imaging, and a proper clinical context must be present. Imaging features of pelvic abscess are commonly characterized by fluid-filled collection with thick and rim-enhancement associated with adjacent inflammatory stranding; gas with an air-fluid level and internal septations may also be observed (15).

RPOC is the most frequent cause of secondary or late postpartum hemorrhage; the frequency of RPOC increases in patients with placenta accreta. Pelvic pain and vaginal bleeding are more common symptoms (8). Correct diagnosis is essential for the appropriate treatment, which commonly requires either medical treatment (administration of uterotonics) or surgical treatment (dilatation and curettage of retained materiel) (4). In this setting, US is generally the first-line of imaging, performed transabdominally and transvaginally with specific consideration of the endometrium (thickened if >10 mm) or any focal hypeechoic masses within the endometrial cavity with increased vascularity at color Doppler US, although the absence of vascularity does not exclude retained products of conception (4, 5, 8). However, the diagnosis of RPOC is sometimes difficult because in a normal uterine postpartum involution, necrotic decidual tissue and blood clots may look like residual tissue (8). MRI should be performed only in patients with inconclusive US findings (8). Sometimes vascular lacunae are visible in RPOC.

On MRI, RPOC is seen as an intracavitary soft-tissue mass with variable enhancement with obliteration of the junctional zone. Although MRI findings of RPOC reveal variations in signal intensity and contrast enhancement, RPOC usually shows very high intensity on T2-weighted images like the normal prepartum placenta. Enhancing tissue may suggest the presence of choriocytic and decidual tissue as well as vascularized granulation tissue (8).

However, in the setting of acute postpartum hemorrhage, CT can be the modality of choice to investigate the source of bleeding. On contrast-enhanced CT images RPOC can be seen as enhancing soft tissue in the endometrial cavity associated with variable degrees of myometrial thinning (Fig. 12) (8, 9). CT findings are not characteristic and sometimes cannot help to discriminate between RPOC and endometritis (9).

Conclusion

With the increasing use of CT as the modality of choice during the immediate post-CS period, familiarity with the normal and abnormal postsurgical findings has become a necessity to avoid misdiagnosis. Unfortunately, CT features of normal CS scar display large variability and there is an important overlap between normal and abnormal postsurgical findings. In this setting, the radiologists should know that some findings such as the presence of myometrial interruption and small hematomas in unusual locations (bladder flap hematoma, subfascial hematoma) do not represent pathologically significant findings, whereas other conditions such as major hematomas, uterine dehiscence, and uterine rupture have to be identified as significant complications. Moreover, given the absence of standardized imaging findings for interpretation of uterine dehiscence and rupture, the radiologic suggestion of complications must be evaluated in view of the clinical setting.

Conflict of interest disclosure

The authors declared no conflicts of interest.

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