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EMERGENCY RADIOLOGY

PICTORIAL ESSAY

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

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ABSTRACT

Vaginal delivery is the most commonly performed delivery in the world and accounts for nearly two-thirds of all deliveries in the United States. It is a secure method but may be associated with some acute complications, especially in the immediate postpartum days, which can potentially be fatal for the mother. The most frequent acute complications are hemorrhages/hematomas, uterine rupture, endometritis, retained product of conception (RPOC), ovarian thrombosis and HELLP syndrome (hemolysis, elevated liver enzymes, low platelet count). A first evaluation of the clinical status of the patients is executed by the clinicians who, depending on their experience, perform ultrasonography by themselves and eventually may request further radiologic exams in doubtful cases. Radiologists may play an important role recognizing early postpartum complications and differentiating them from physiologic postoperative findings. In this setting, the use of multidetector computed tomography (MDCT) is important for diagnosis of suspected postpartum complications. The aim of this article is to review the normal and abnormal post vaginal delivery MDCT aspects in order to help the clinical management by preventing misdiagnoses and tailoring the best medical treatments.

The role of the radiologist in the diagnosis of acute delivery complications is crucial in clinical practice, mainly in those conditions that are potentially fatal. The postpartum period refers to the time interval from birth to 6–8 weeks later (1).

The most common acute complications for vaginal delivery are hemorrhages/hematomas, uterine rupture, endometritis, retained products of conception (RPOC), ovarian thrombosis, and HELLP syndrome (hemolysis, elevated liver enzymes, low platelet count) (2) (Table). These conditions are suspected by the gynecologist on the basis of clinical and biochemical data. As usual practice, ultrasonography (US) is performed as the first line examination. However, in doubtful cases, multidetector computed tomography (MDCT) may help in making a prompt diagnosis and in determining the presence and severity of complications (3). Radiologists should know the common and uncommon findings of the pelvis after vaginal delivery and the physiopathology underlying these complications in order to facilitate diagnosis and treatment of the complications. Unfortunately, the difficulty of postpartum imaging interpretation is related to the wide variability of MDCT appearance of postpartum uterine and pelvic findings. Moreover, these types of CT examinations are not so frequent due to the controversial use of intravenous iodinated contrast agent in patients who are breastfeeding and due to the fact that breast tissue is hyper-radiosensitive in the post delivery period. Because of data supporting the carcinogenic effects of ionizing radiation on the proliferating breast epithelium (4), a clinical decision for imaging should be carefully evaluated, always keeping to the "as low as reasonably achievable" (ALARA) approach (5). To reduce the risk of radiation, adjustments such as modulation of tube current and voltage, diminishing the scanned volume, increasing the pitch, widening the beam collimation and iterative reconstruction techniques should always be considered.

The aim of this paper is to review pelvic anatomy and normal and abnormal post vaginal delivery findings in order to help radiologists to identify acute complications and avoid possible misdiagnosis. Moreover, a multidisciplinary approach is necessary to optimize the role

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Table. Imaging of acute complications after vaginal delivery

Acute complications	Imaging features	Associated findings
Hemorrhages	Diffuse contrast extravasation Hyperattenuating blood or fluid collection Hematomas	Detection of the bleeding site and intraabdominal extension Myometrial disruption and hemoperitoneum
Uterine rupture	Complete rupture of the uterine wall with separation of all layers (including serosal) and direct communication between uterine and peritoneal cavity	Large amount of blood Infection of the myometrium or parametrial abscess Direct communication with the endometrium
Retained product of conception (RPOC)	Enhancing soft-tissue mass within the endometrial cavity	Variable degree of myometrial thinning
Ovarian vein thrombosis and thrombophlebitis	Enlarged and tubular ovarian vein (or other pelvic veins) expanded by intraluminal low-density thrombus, surrounded by enhancing vessel wall	Perivascular adjacent inflammatory stranding
Endometritis	Thickened and distended endometrial cavity by fluid, gas or debris	Endometrial enhancement can be depicted on contrast-enhanced images

of diagnostic and interventional radiology, thus providing minimally invasive treatments and supporting the management, without unnecessary surgical interventions.

Vaginal delivery

Vaginal delivery, despite the increasing rate of cesarean section, still remains the most common kind of delivery performed in the world. Despite worldwide decrease in maternal mortality between 1990 and 2015, pregnancy continues to be an important source of mortality in young women in the postpartum period (6, 7). Risks of vaginal delivery depend on many factors such as maternal age, previous cesarean delivery, birth weight, neonatal head circumference, and fetal presentation (8, 9). Vaginal delivery is usually a safe procedure. However, a variety of early complications may occur during the post vaginal birth period.

Main points

- Different acute complications may follow a vaginal delivery, such as hemorrhages/hematomas, uterine rupture, endometritis, retained product of conception, ovarian thrombosis, and HELLP syndrome.
- Ultrasonography and multidetector computed tomography are the most frequently used methods to detect the acute complications after vaginal delivery.
- During the first days after vaginal delivery, it is not easy to differentiate normal appearances from possible acute complications because there is an important overlap between normal and abnormal post vaginal delivery findings.
- Given the absence of standardized imaging findings, the radiologic suggestion of complications must be evaluated in the appropriate clinical settings.

Imaging

US, MDCT, and magnetic resonance imaging (MRI) are the most utilized imaging techniques to diagnose possible acute complications after vaginal delivery.

US is the most common imaging modality because it is a noninvasive and low-cost technique, it does not use ionizing radiation, and it can be performed at the bedside. Endovaginal US can show a good visualization of the uterus, ovaries, and adnexa, while transabdominal US is more adequate to evaluate abdominal organs. However, US is an operator-dependent imaging modality and has limited spatial resolution. When US findings are dubious, MDCT is the technique of choice in patients with acute symptoms and suspected complications. MDCT is being increasingly used in the setting of life-threatening conditions, especially for suspected post vaginal delivery complications such as arterial bleeding. MDCT is usually performed employing a protocol which includes three phases: an unenhanced scan of the pelvis followed by contrast-enhanced arterial and venous phase scans including the whole abdomen or only the pelvis for the arterial phase (10). The unenhanced scan helps to depict hyperattenuation typical of hematomas or free intraabdominal fluid and it is also useful for discriminating active bleeding from metal clips, hemostatic material, gauzes, and calcifications. Arterial phase scans improve the identification of active bleeding. Venous phase scans permit to discriminate active arterial bleeding from active venous bleeding, pseudoaneurysm and engorged vessels (2). A further delayed scan obtained after 3–5 minutes from the contrast injection may be performed in doubtful cases, such as unclear active bleeding during the arterial and venous phases or if a urinary bladder lesion is suspected. The three-phase technique has the limitation of an important amount of radiation exposure. In order to decrease the exposure to radiation in young breast-feeding women, low-dose scanning protocols can be adopted. In this setting, acquisition of the arterial and portal phase only to the pelvis or the adoption of alternative protocols with two phases should be taken into consideration. A two-phase MDCT that includes the unenhanced phase and enhanced phases or two enhanced phases without the unenhanced phase has been proposed. There are controversial opinions regarding the use of an unenhanced CT scan or whether to employ the arterial or the venous phase to better show the site of bleeding (11).

MDCT permits several postprocessing techniques such as multiplanar reconstructions (MPR) and volume rendering imaging, useful for evaluation of fine anatomic details and vessels and necessary in case of endovascular treatment planning. MDCT is commonly preferred to MRI because of its availability, cost effectiveness, and faster modality of study.

MRI is usually considered a third choice because it is not commonly available and

requires long acquisition times. MRI is usually performed when US and MDCT findings are inconclusive or in case of patients with contraindication to intravenous administration of iodine contrast medium. MRI has an excellent soft-tissue contrast and is highly capable in demonstrating uterine zonal anatomy and pelvic structures. MRI is performed using a 1.5 T or 3 T scanner and a phased array multi-coil. The protocol should include pelvic axial T1- and T2-weighted sequences with and without fat suppression, acquired in three planes. Dynamic contrast enhanced T1-weighted sequences are acquired after an intravenous bolus injection of chelate of gadolinium (10).

Normal postpartum findings on MDCT

Physiologic changes occur in women during pregnancy and the puerperal period. The most rapid modifications take place in the first three days after delivery. The postpartum uterus has a variable appearance that varies according to the time after birth. The uterus is typically enlarged, measuring twice its normal pre-gravid dimension and requires 6–11 weeks to involute and return to the pre-gravid size (Fig. 1) (2).

A normal uterus measures approximately 20 cm in length after delivery but decreases by nearly 50% in the first 24–48 hours (1). After a few days, the uterine involution is moderate, with the uterus measuring approximately 10 cm in length at 3 weeks and 8 cm at 6 weeks postpartum. Endometrial thickness in the postpartum period is usually less than 2 cm. The normal appearance of a postpartum uterus can be confused with a pathologic one because sometimes there is an overlap between normal and abnormal findings. The presence of small amounts of blood, fluid or gas in the endometrial cavity is not necessarily indicative of a complication and can be present in the first few days after vaginal delivery and even until one week postpartum. The presence of endometrial blood clots diminishes over time; however, a small amount of complex fluid may persist for 3 weeks after delivery. Also intracavitary gas, commonly believed to be a manifestation of endometritis, is a normal finding in asymptomatic women and can persist for 3 weeks after delivery. The identification of ovarian arteries on contrast-enhanced MDCT may be difficult because they are smaller than ovarian veins.

Fluid and lochia with small amounts of gas are commonly seen in MDCT as a central lower density area of less than 2 cm in asymptomatic women. If larger amounts of fluid, gas or soft tissue are present, a clinical correlation is necessary to rule out endometritis and RPOC. Sometimes, intravaginal gauze can be recognized as a hyperattenuating image (Fig. 2).

On US, the myometrium appears heterogeneous with an echogenicity higher than

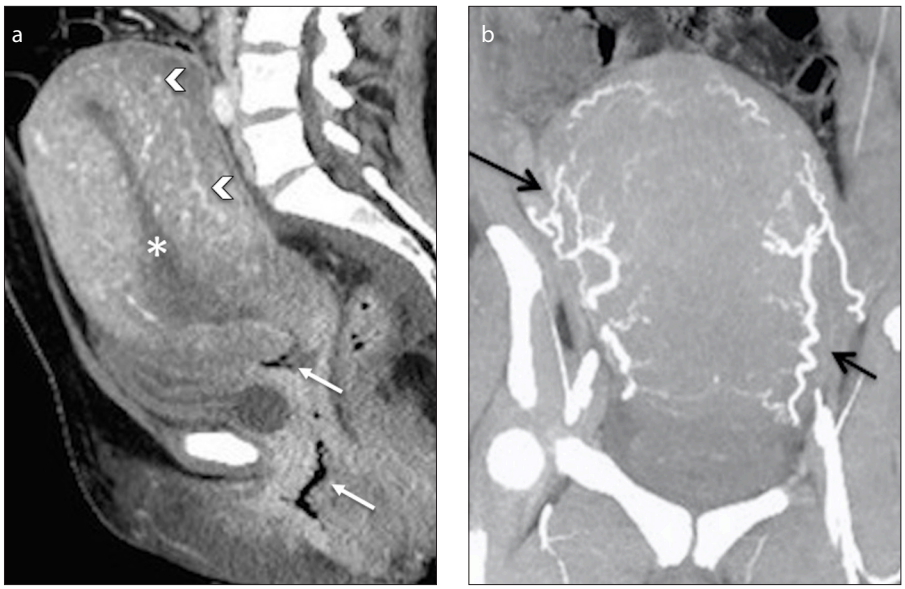

Figure 1. a, b. Normal MDCT findings of uterus and uterine arteries in a 34-year-old woman 1 day after spontaneous vaginal delivery. Sagittal contrast-enhanced venous phase MDCT image through the pelvis **(a)** shows an enlarged uterus with a low-attenuation central area *(asterisk)* corresponding to intrauterine blood debris and fluid. Intrauterine and intravaginal gas bubbles are also present *(white arrows)*. Note the increased uterine vascularity. Intramural arterial uterine branches appear as dot-like or tubular enhancing structures in the myometrium *(arrowheads)*. Oblique coronal maximum intensity projection (MIP) reformatted image **(b)** better demonstrates the bilateral myometrial arterial uterine branches and the cervico-vaginal branches of the uterine artery as several tortuous enhancing tubular vessels *(black arrows)*.

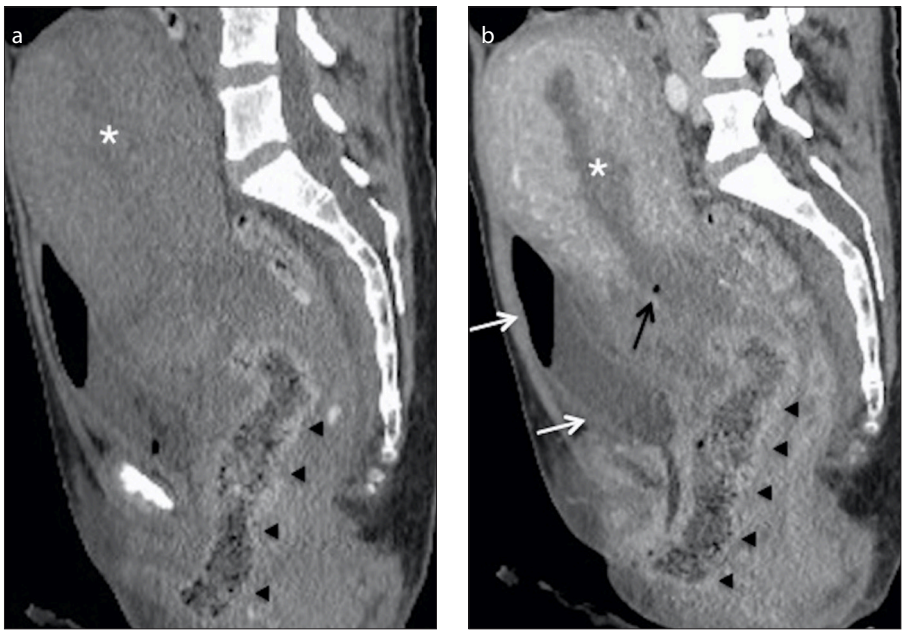

Figure 2. a, b. Metrorrhagia in a 30-year-old woman with anemia and vaginal laceration, 1 day after spontaneous vaginal delivery. Sagittal unenhanced MDCT image **(a)** shows a normal enlarged uterus after vaginal birth with intrauterine amount of fluid and blood debris *(asterisk)*, better demonstrated on sagittal contrast-enhanced venous phase **(b)**. Some gas bubbles can also be seen within the cervical canal *(black arrow)*. Vaginal packing with rolled gauzes is visualized in the vagina *(black arrowheads)* and it is used to tamponade the bleeding. The bladder is moderately distended by urine and air due to presence of the catheter *(white arrows)*.

the myometrium of a nongravid uterus. Moreover, the presence of hyperechoic endometrial material is a normal finding without any pathologic relevance. In asymptomatic women, after birth, the uterus can show hypervascular signals on color Doppler images due to increased myometrial vascularity at the placenta insertion site.

The vascular supply of the uterus derives from bilateral uterine arteries, which arise from the anterior separation of the internal iliac vessel. The uterine arteries cross beyond the ureter and provide a ureteric branch as they pass in the parametrium. In the parametrium, the uterine arteries give two predominant ramifications: an ascending vessel that moves cranially and provides the myometrial arteries, and the cervico-vaginal vessel that moves caudally. The uterine arteries also supply the tubes and the ovaries.

The vaginal arteries, which originate from the anterior trunk of the internal iliac artery, supply the vagina, vulva, vesical fundus and rectum. The ovarian arteries arise from the abdominal aorta below the emergence of the renal arteries and supply the fallopian tubes and the ovaries. In the pelvis, ovarian arteries get to the suspensory ligament of the ovary and penetrate the ovary at the mesovarian border. Genital organs possess abundant arterial anastomoses securing huge vascularization: uterine arteries intercommunicate with the ovarian arteries by ovarian and tubal vessels and also with the vaginal arteries and round ligament arteries. Every collateral anastomosis must be contemplated as a possible origin of bleeding.

Contrast-enhanced MDCT performed in the first few days after vaginal delivery may show an expanded uterus with thickened endometrium and increased myometrial enhancement. The endometrial thickness is better evaluated on sagittal reformatted images in a manner similar to US (12). The uterine and ovarian arteries are usually prominent in postpartum due to increased blood flow during pregnancy. On contrast-enhanced MDCT the uterine arteries are visualized as tubular enhancing vessels in the parametrium. Intramural branches can be visualized as dot-like enhancing structures in the outer myometrium. Expanded vascularity of the myometrium may be a normal postpartum finding in the absence of abnormal bleeding.

MRI typically demonstrates loss of zonal anatomy of the uterine body, while the zonal anatomy of the cervix is mainly preserved. Myometrium shows intermediate signal intensity on T2-weighted images. The endometrial cavity reveals variable signal intensity depending on the presence of endometrial blood products. Myometrial conspicuous vascularity is seen as multiple T2-weighted hyperintensities corresponding to the myometrial vessels giving a "combed" appearance of the myometrial wall. High signal intensity of the cervical stroma on T2-weighted images may reflect edema. Parametrial edema can also be seen on T2-weighted images. A normal zonal anatomy is usually recognizable six months after delivery.

Abnormal findings in the postpartum: acute complications

Hemorrhages

Postpartum hemorrhage (PPH) is one the most frequent complications after vaginal delivery and can be lethal if not quickly diagnosed (13). The incidence of maternal mortality due to postpartum hemorrhages varies between countries, registering higher rates in developing countries (1 in 1000 deliveries) and lower rates in developed countries (1 in 10 000 deliveries) (14). The PPH rate is increasing (15). Primary or early PPH is defined as blood loss greater than 500 mL within the first 24 hours after delivery and occurs in 4%–6% of deliveries. Because of the difficulty to estimate blood loss, a more clinical definition of postpartum hemorrhage is blood loss causing hypovolemia characterized by low blood pressure (systolic blood pressure <90 mmHg), oliguria (diuresis rate <0.5 mL/Kg/h), and tachycardia (heart rate >100 bpm). A mnemonic rule (11) can be used to remember the four main risk factors of PPH: "4 Ts", which stand for tonus, tissue, trauma, thrombin. In 75%–90% of cases primary PPH is caused by uterine atony (11, 16). The diagnosis of uterine atony is clinical and can result from different causes such as multiple gestations, extended labor, large fetal size, use of oxytocin for induction, uterine rupture, trauma of the lower portion of the genital tract, uterine inversion, retention of blood clot, abnormal placentation or incomplete placental delivery, acquired or congenital coagulation disorders.

Secondary or late postpartum hemorrhages are considered all the hemorrhages which begin after more than 24 hours to six weeks after delivery (2). Secondary postpartum hemorrhages are less common (incidence rate 1%–2% of deliveries) and may be caused by RPOC, uterine subinvolution, endometritis, acquired or congenital coagulopathies or abnormalities of the uterine vasculature. MDCT is the preferred imaging technique in puerperal women with suspected uterine hemorrhage (17). On contrast-enhanced CT images, uterine hemorrhages caused by active bleeding are easily recognized as an extravasation of contrast media in the uterine cavity during the arterial or venous phases. A comparison with unenhanced CT images is useful to differentiate intravenous contrast media extravasation from other preexisting high attenuation materials (Fig. 3) (17).

Laceration of the inferior portion of the genital tract is a complication that occurs in 2%–4% of PPH, especially after instrumental vaginal delivery. The inferior portion of the genital tract includes cervix, vulva, and perineum. Bleeding originating in these sites can possibly grow into a paravaginal hematoma. Based on their connection to the levator ani muscle, paravaginal hematomas are classified into supralevator or infralevator (11). This kind of differentiation is extremely important in clinical management. In fact, hematomas confined to the infralevator paravaginal space are easily recognized during inspection after delivery because of their extension to the vulva, perineum, and ischio-rectal fossa. If necessary, the treatment of choice is transvaginal drainage.

Supralevator hematomas can extend into the paravaginal fasciae and broad ligament toward the upper abdomen. Supralevator hematomas are more difficult to identify and the diagnosis may be delayed because they are not associated with vaginal bleeding. Patients with supralevator hematomas and abdominal pain may quickly develop a hypovolemic shock. This condition should always be considered in case of symptomatic patients without uterine atony. An MDCT examination is necessary to evaluate the presence and the extension of hematomas and to identify any possible source of active bleeding (16). In unenhanced MDCT, acute and subacute hematomas show heterogeneous high attenuation (70–90 HU) while chronic hematomas present low attenuation. In contrast-enhanced MDCT, hematomas show well-defined margins and absence of contrast enhancement (13). The use of contrast is mandatory to rule out the suspicion of active bleeding. Iodinated contrast extravasation in the arterial phase

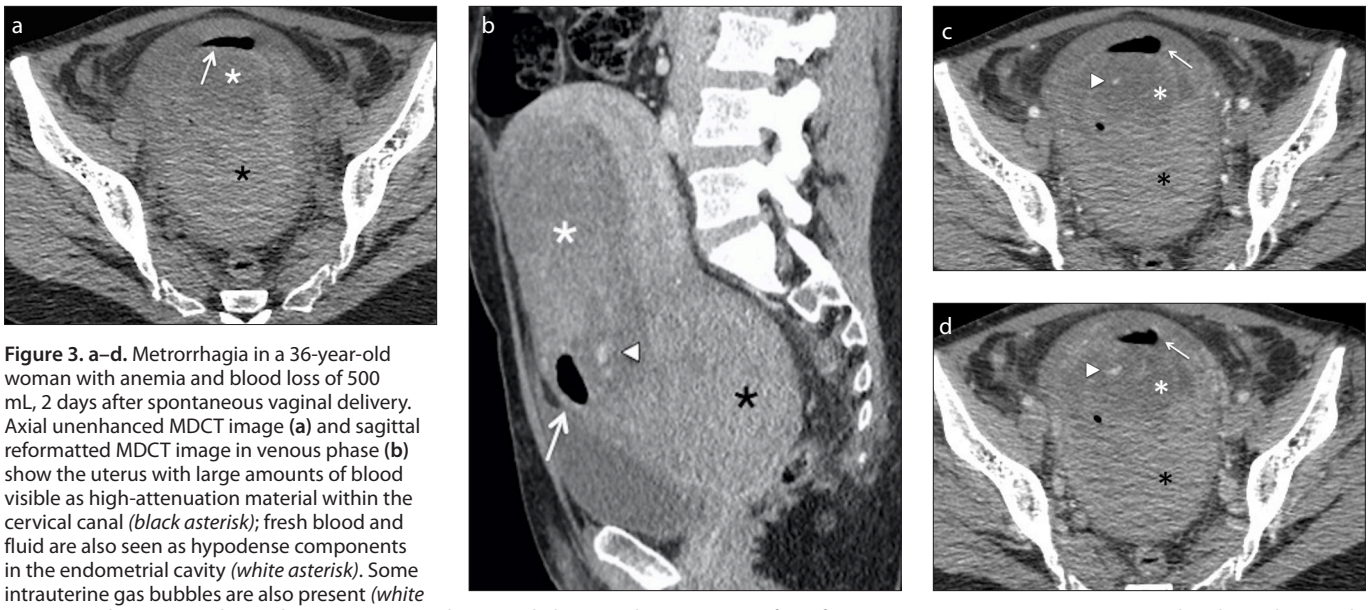

Figure 3. a–d. Metrorrhagia in a 36-year-old woman with anemia and blood loss of 500 mL, 2 days after spontaneous vaginal delivery. Axial unenhanced MDCT image **(a)** and sagittal reformatted MDCT image in venous phase **(b)** show the uterus with large amounts of blood visible as high-attenuation material within the cervical canal *(black asterisk)*; fresh blood and fluid are also seen as hypodense components in the endometrial cavity *(white asterisk)*. Some intrauterine gas bubbles are also present *(white arrow)*. Axial contrast-enhanced MDCT images in the arterial phase **(c)** shows punctate foci of intrauterine contrast extravasations within the endometrial cavity increasing in venous phase **(d**, *white arrowhead)*. Two days after delivery, operative exploration confirmed blood clots and the presence of retained placental tissue.

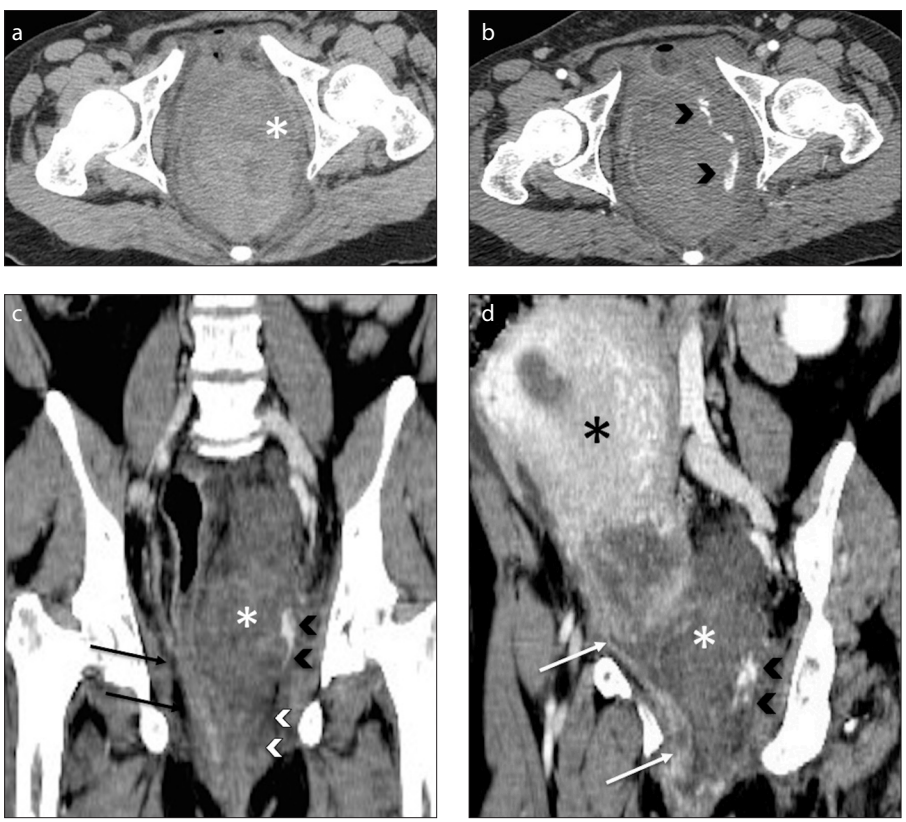

Figure 4. a–d. Supralevator paravaginal hematoma in a 29-year-old woman, 1 day after spontaneous vaginal delivery, with clinical suspicion of hematoma of vaginal wall. Axial unenhanced MDCT image **(a)** demonstrates a high-attenuation collection due to fresh blood *(white asterisk)* located in left paravaginal extraperitoneal space. Axial contrast-enhanced MDCT image in the arterial phase **(b)** shows active bleeding *(black arrowheads)*. Coronal **(c)** and oblique sagittal **(d)** reformatted MDCT images depict the position of the hematoma *(white asterisk)*, contrast extravasation, and the source of the bleeding from the vaginal arteries *(black arrowheads)*. Moreover, the MPR images clearly show the relationship between the hematoma *(white asterisk)*, levator ani muscle *(white arrowheads)*, rectum *(black arrows)* and vagina *(white arrows)* which are both contralaterally dislocated. The patient underwent selective arterial embolization.

that enlarges during the portal venous phase is the typical finding of bleeding (Figs. 4 and 5) (18).

A pelvic MRI may be helpful to determine the real expansion of hematomas in the pelvis, their age, their relationships with the pelvic structures and to follow-up their evolution (11). In MRI, acute and subacute hematomas show hyperintensity on T1- and T2-weighted images, while chronic hematomas show hypointensity on T1- and T2-weighted images (Fig. 6).

Most uterine bleedings are small and self-resolving, while some others require routine medical management. If medical treatment is not sufficient, there are two types of therapeutic options: surgical treatments and endovascular treatments such as uterine artery embolization (UAE). Surgical treatments include suture repair of vulvovaginal tears, intrauterine tamponade procedures, uterine compression sutures, arterial ligation or hysterectomy (8, 19). UAE is usually recognized to be a safe and reliable procedure. Embolization should be performed in the following three cases: uterine atony after conservative treatments fail, trauma of the inferior part of the genital area if surgical procedures have failed, and active intraabdominal bleeding (Fig. 7) (11).

Uterine rupture

Uterine rupture is a sporadic but possibly fatal complication which may develop

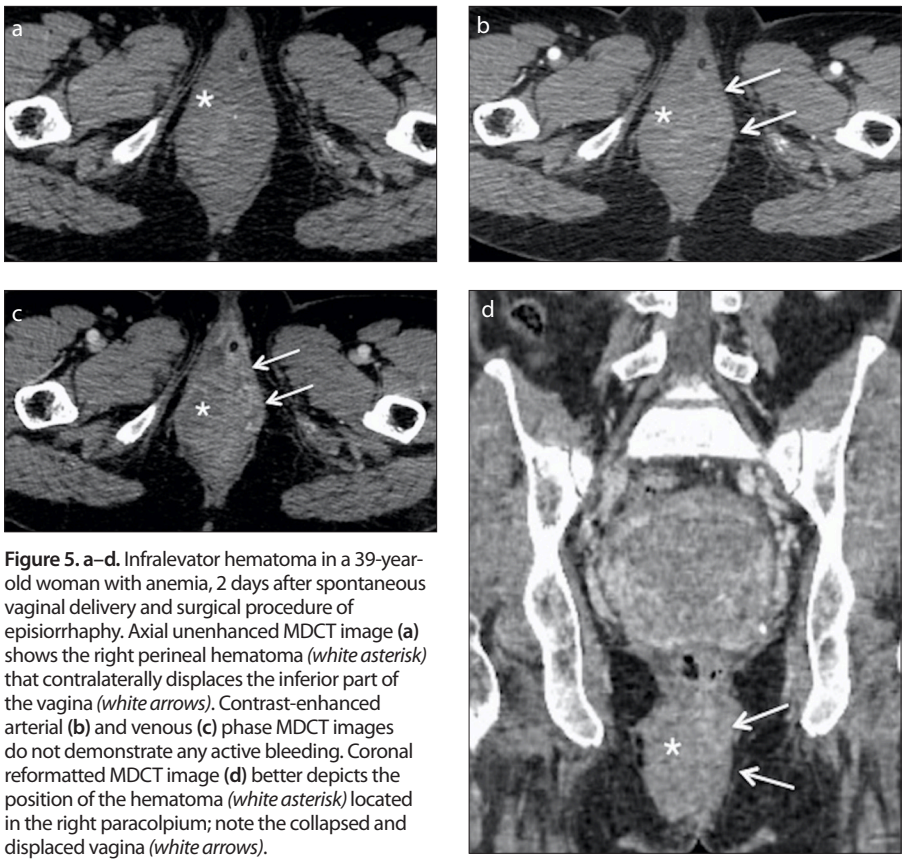

Figure 5. a–d. Infralevator hematoma in a 39-year-old woman with anemia, 2 days after spontaneous vaginal delivery and surgical procedure of episiorrhaphy. Axial unenhanced MDCT image **(a)** shows the right perineal hematoma *(white asterisk)* that contralaterally displaces the inferior part of the vagina *(white arrows)*. Contrast-enhanced arterial **(b)** and venous **(c)** phase MDCT images do not demonstrate any active bleeding. Coronal reformatted MDCT image **(d)** better depicts the position of the hematoma *(white asterisk)* located in the right paracolpium; note the collapsed and displaced vagina *(white arrows)*.

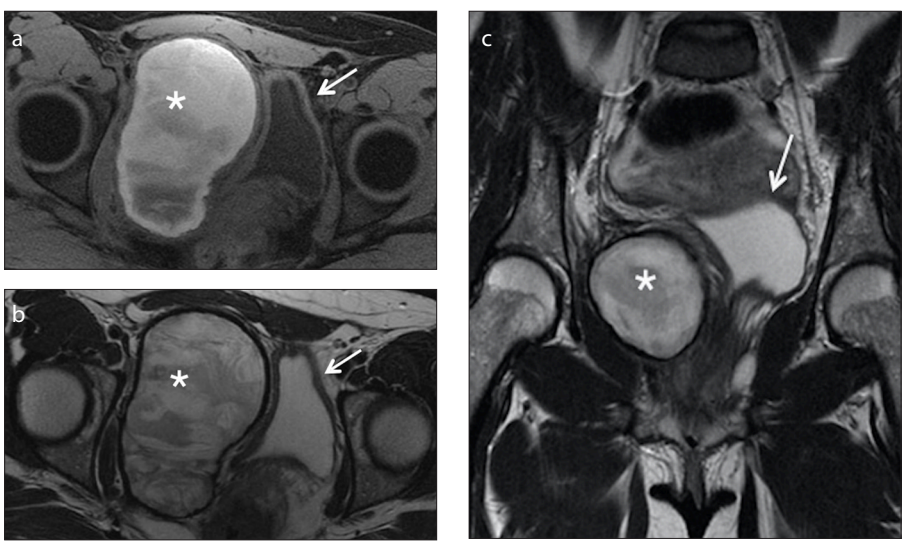

Figure 6. a–c. Supralevator hematoma in a 34-year-old woman with vaginal delivery complicated by an active pelvic bleeding treated with selective arterial embolization. MRI of the pelvis was performed several weeks after vaginal birth to follow up the extraperitoneal extensive hematoma previously evaluated with a MDCT scan *(not shown)*. Axial T1-weighted fat-suppressed **(a)** and T2-weighted **(b)** images show the hematoma located in the right paravesical and paracolpium spaces *(white asterisk)* with lateral displacement of the bladder *(white arrow)*. Coronal T2-weighted image (c) better shows cranial and lateral displacement of the bladder *(white arrow)*.

before, during or immediately after labor in women who have predisposing conditions. These conditions may include vaginal delivery after previous cesarean section, previous uterine surgery or curettage, congenital uterine malformations, prolonged oxytocin induction, and retroflexion uterus due to adhesions (20).

Uterine rupture is the disruption of all the layers of the uterus including the myometrium and serosa. Diagnosis is often clinical with acute severe abdominal pain and vaginal bleeding but sometimes it occurs without any pain. A suspected uterine rupture needs treatment to prevent the risk of hypovolemic shock due to intraperitoneal hemorrhage.

MDCT finding of uterine rupture is low attenuation defect within the otherwise densely enhancing myometrium, indicative of the disruption of the uterine wall (21). If the uterine rupture takes place before the onset of labor it commonly affects the corpus either anterior or posterior myometrium; in women who have prolonged labor the rupture frequently takes place in the thinned lower uterine segment (Fig. 8) (3). Another important finding to look for is hemoperitoneum, because it can lead to hypovolemic shock and death (Fig. 9).

Endometritis

Endometritis is the most frequent source of postpartum fever that should be suspected after vaginal delivery in febrile postpartum patients with raised inflammatory markers. The diagnosis is always clinical. Recognizing this complication is of paramount importance because it can develop into myometritis, pelvic abscess, and septic thrombophlebitis (3).

MDCT features of endometritis are the evidence of fluid or gas in the endometrial cavity; after administration of contrast medium, the endometrium walls will show diffuse enhancement. However, these findings can also be found in the normal postpartum uterus. The difficulty in making an accurate diagnosis is enhanced by the significant overlap between the imaging findings of a normal post-gravid uterus and endometritis.

In enhanced MDCT, pelvic abscesses show low attenuation in the central area that corresponds to the necrotic inflammatory component and well-defined thickened walls with rim-enhancement. Sometimes abscess can show an air-fluid level or internal septations or exert a mass effect on the adjacent structures with associated peritoneal fat stranding as a result of inflammatory changes. If the amount of air within the abscess is considerable, a bowel perforation or fistulous communication should be suspected. MPR-MDCT allows to document the real extension of the abscess and to identify

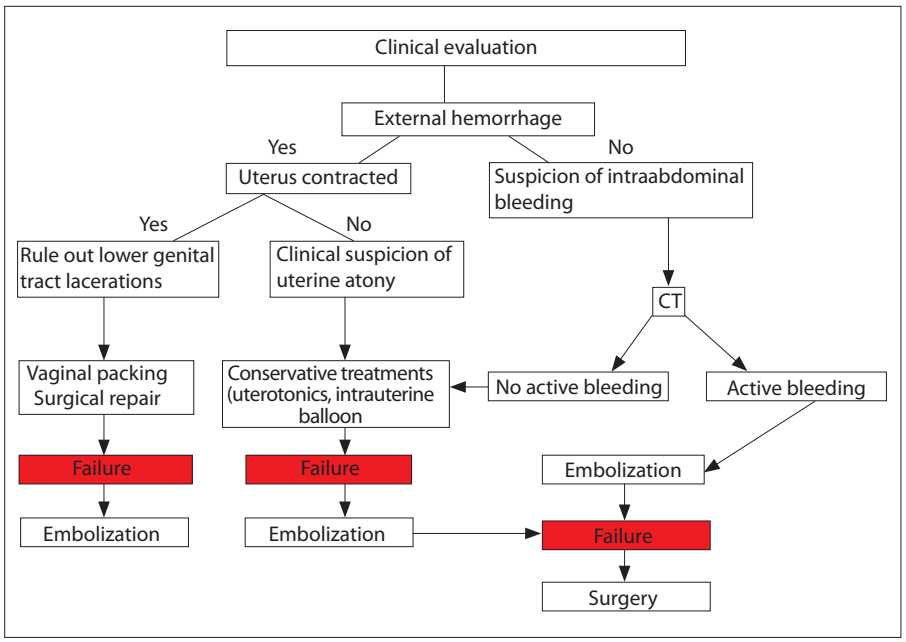

Figure 7. Proposed algorithm for the management of postpartum hemorrhage modified from Sierra et al. (11).

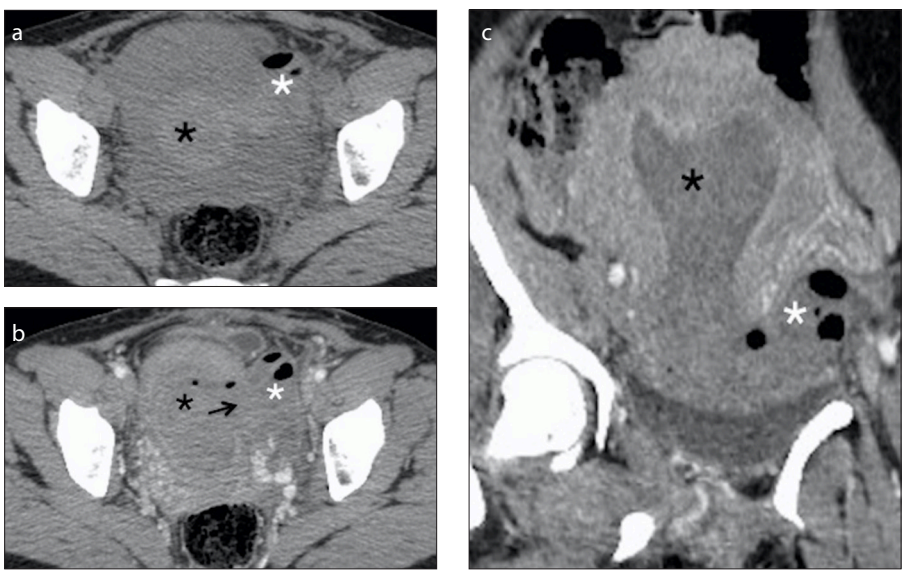

Figure 8. a–c. Uterine dehiscence in a 36-year-old woman with pelvic pain, hyperpyrexia and clinical suspicion of uterine perforation, 7 days after spontaneous vaginal delivery. The patient had a previous cesarean delivery. Axial unenhanced **(a)** and contrast-enhanced MDCT images **(b)** show the uterus with a defect on the left side of myometrial wall (**b,** *black arrow)* associated to a hyperattenuating gas containing fluid collection *(white asterisk)*. Endometrial cavity is distended by fluid, blood debris, and gas bubbles *(black asterisk)*. Coronal reformatted MDCT image in venous phase **(c)** better depicts the communication between the distended endometrial cavity *(black asterisk)* and the fluid collection *(white asterisk)* and its extension in the left extraperitoneal parauterine space. The patient was surgically treated and the uterine dehiscence was confirmed.

bowel perforation or the exact localization of fistulous communication.

Ovarian vein thrombosis and thrombophlebitis

Ovarian vein thrombosis (OVT) has an incidence of 0.5–1.8:1000 deliveries during postpartum (22).

Ovarian veins may be compressed by the enlarged uterus. This condition causes venous stasis, a risk factor for thrombosis (23). In 90% of cases thrombosis is unilateral, arising more commonly in the right ovarian vein (3). The left one is protected by the retrograde flow from the renal vein. A thrombus in the right vein can spread to the inferior vena cava. Patients usually present fever (24), pelvic pain, and sometimes a lower pelvic mass can be palpable.

US is not useful in making a diagnosis because the bowel gas limits the study of the abdominal organs. MDCT or MRI are usually required to confirm the clinical suspicion.

Contrast-enhanced MDCT appearance of ovarian vein thrombosis is an enlarged ovarian vein with wall enhancement and a low-density thrombus in the lumen. A surrounding inflammatory reaction can be seen as ill-defined soft tissue density following the course of the ovarian vein.

In patients with endometritis, thrombophlebitis may complicate a bland thrombus, and in this case the diagnosis is supported by perivascular stranding combined with a dilated gonadal vein.

Possible differential diagnoses to consider are appendicitis, ovarian torsion, phlegmon or hematoma of broad ligament, pelvic or abdominal abscess, urolithiasis, and pelvic cellulitis.

Uterine venous plexus thrombosis is a rare postpartum complication usually related to pelvic septic thrombophlebitis in febrile puerperal patients. It is an underdiagnosed condition that can be seen more clearly by transvaginal US and later confirmed by MDCT scan or MRI (Fig.10).

On US, the thrombus appears as a round echogenic area inside the lumen of uterine dilated veins. The use of color Doppler US is useful to show the thrombus as a filling defect in the venous lumen and to differentiate dilated uterine varicose veins from other pathologic nonvascular conditions such as hydrosalpinx and peritoneal inclusion cysts (25). Anticoagulants and antibiotics are treatments of choice for this condition.

Retained products of conception (RPOC)

RPOC is considered to be one of the most frequent causes of PPH. RPOC consists of persistent placental or trophoblastic tissue within the uterine cavity after delivery, miscarriage or termination. The incidence rate of RPOC after vaginal delivery is 3%–5% (26). Distinguishing RPOC from natural postpartum lochia or uterine atony is not easy. An accurate diagnosis is made by analyzing clinical, laboratory, and radiologic findings. However, the only correct diagnosis can be obtained through microscopic analysis, which demonstrates the existence of chorionic villi and reveals

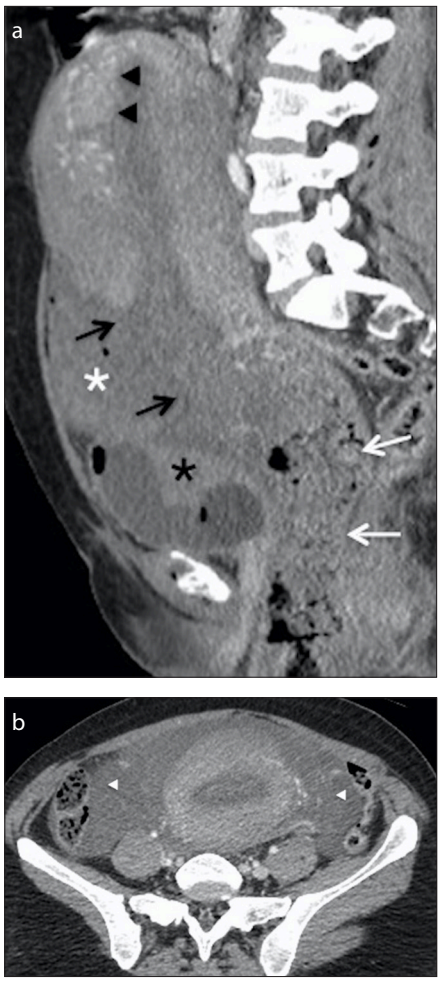

Figure 9. a, b. Uterine dehiscence in a 35-year-old woman with unstable vital signs, hematuria and vaginal lacerations, 1 day after spontaneous vaginal delivery. The patient had a previous cesarean delivery. Sagittal reformatted MDCT image in venous phase **(a)** shows a uterus with a large irregular defect in the anterior myometrial wall at the isthmus (site of prior cesarean section) *(black arrows)*. Anterior to the uterus there is a hyperattenuating fluid collection containing gas bubbles corresponding to a bladder flap hematoma *(white asterisk)*. Posterior bladder wall is irregular with loss of clear border. Hyperattenuating material is visible within the lumen of the bladder *(black asterisk)* above the catheter. The endometrial cavity is moderately distended and there is increased myometrial vascularity in the fundus at the site of the placental insertion *(black arrowheads)*. Note the vaginal packing with rolled gauzes within the vagina *(white arrows)*. Axial enhanced MDCT image **(b)** demonstrates a big amount of hemoperitoneum *(white arrowheads)*. Symptoms and images suggested uterine rupture with associated bladder laceration. The patient was surgically treated, and uterine dehiscence and bladder rupture were confirmed.

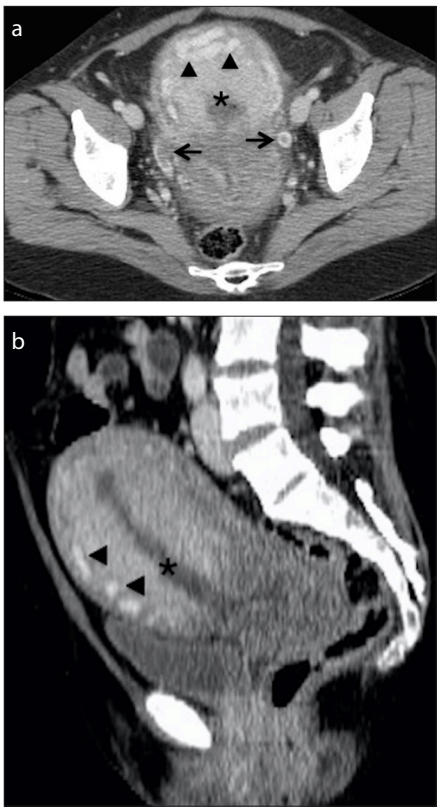

Figure 10. a, b. Uterine vein thrombosis in a 45-year-old woman with clinical suspicion of chorioamnionitis, 1 day after spontaneous vaginal delivery. Axial contrast-enhanced venous phase MDCT image **(a)** shows luminal filling defect within the right and left uterine veins *(black arrows)*. In the axial **(a)** and sagittal **(b)** contrast-enhanced MDCT images, note the increased dimension of the uterus with an increased myometrial vascularity *(black arrowheads)*. Moderate amount of intrauterine fluid is also present *(asterisk)*.

the persistence of placental tissue. Women with RPOC present with uterine bleeding and pain or fever. Serum beta human chorionic gonadotropin levels (β-hCG) are not useful in the diagnosis because they can be elevated in the postpartum period. When RPOC is suspected, endovaginal US should be performed. The presence of intrauterine mass with vascular signals at power Doppler and thickened endometrium (ranging from 8–13 mm) can suggest RPOC (3, 11, 17). If US findings are ambiguous MRI can be useful. However, in the setting of acute postpartum hemorrhage, MDCT can be the modality of choice to investigate the source of bleeding. The presence of a heterogeneous enhancing soft tissue in the endometrial cavity associated with variable degrees of myometrial thinning is a typical sign of RPOC (3) (Fig.11).

However, these findings can also be observed in the early postpartum period in patients without RPOC. It is important to recognize RPOC because patients undergo curettage procedure. The main differential diagnosis is with gestational trophoblastic disease (GTD) that derives from the anomalous proliferation of trophoblastic tissue. GTD could have the same MDCT characteristics but also has persistently elevated serum β-hCG levels (RPOC has normal or only moderately high β-hCG levels). Moreover, diagnostic pitfalls that can mimic RPOC include uterine arteriovenous malformation (AVM), invasive moles, blood clots, subinvolution of the placental implantation site. AVM consists of a proliferation of vessels with development of many arteriovenous fistulous connections within the uterus without an intervening capillary network. An early diagnosis allows to avoid and prevent complications such as perforation or infection.

HELLP syndrome

HELLP syndrome is a life-threatening complication described as the combined occurrence of hemolysis, elevated liver enzymes, and low platelet count (27). It is usually considered to be a variant of preeclampsia and it occurs in among 4%–12% of patients with preeclampsia as an existing condition (20). It is associated with high maternal and perinatal mortality.

Diagnosis of HELLP syndrome is based on both clinical and biochemical criteria. The role of imaging is only to support the diagnosis and to identify possible associated complications and their severity (3). Multiorgan system dysfunction with possible development of placental abruption, acute renal failure, pericardial or pleural effusion can develop as a result of intravascular fibrin deposition.

Abdominal pain, especially in the right upper quadrant, can be the only symptom of hepatic involvement. Elevation of serum bilirubin due to peripheral hemolysis and hepatocyte necrosis is often found as a biochemical marker. Fibrin deposits within the hepatic sinusoids can lead to progressive obstruction of the hepatic blood flow, liver hemorrhage, subcapsular hematoma, and hepatic rupture with hemoperitoneum. MDCT scans usually show a low attenuation wedge-shaped area in the periphery of the liver that correlates with the region of liver necrosis.

Conclusion

The use of MDCT as the modality of choice during the early postpartum period requires that the radiologist become

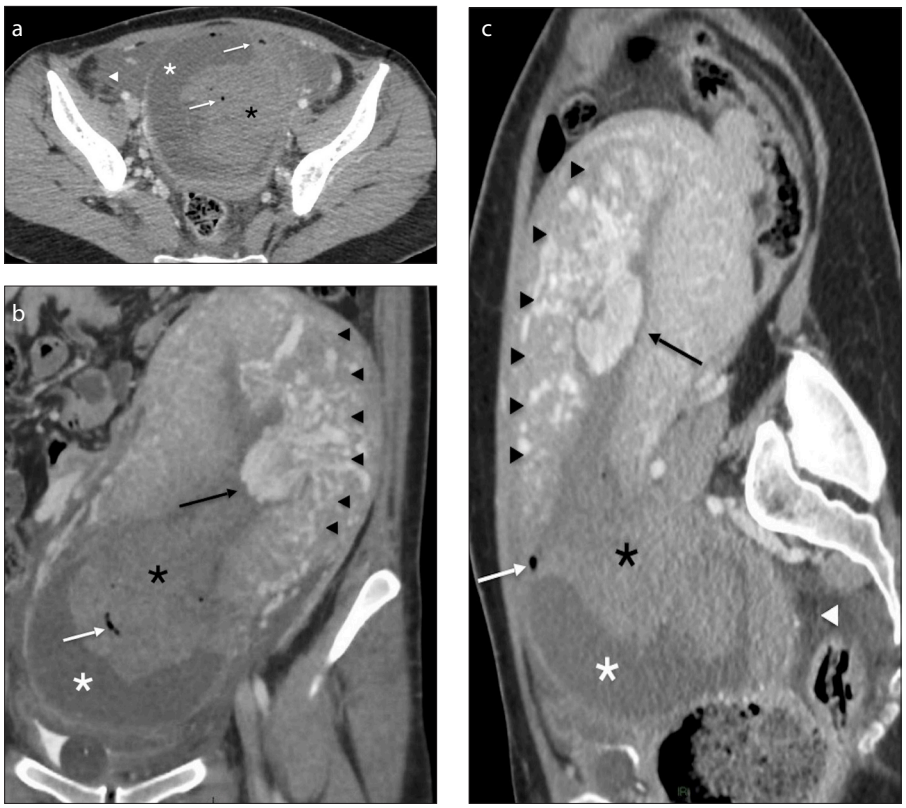

Figure 11. a–c. Retained products of conception (RPOC) in a 37-year-old woman with endometritis, metrorrhagia and anemia, 2 days after spontaneous vaginal delivery. Axial contrast-enhanced CT image **(a)** demonstrates a big blood clot *(black asterisk)* associated to a fluid collection *(white asterisk)* and air bubbles *(white arrows)* within the endometrial cavity. Note the fluid collection in the peritoneum *(white arrowhead)*. Oblique coronal **(b)** and oblique sagittal **(c)** reformatted MDCT images in venous phase show a high enhancing soft-tissue mass *(black arrow)* in the anterior myometrial wall, protruding into the endometrial cavity. Note the hypervascularity of the myometrium of the anterior uterine wall *(black arrowheads)* due to RPOC. Operative exploration confirmed retained placental tissue.

familiar with normal and abnormal postpartum findings. The role of the radiologist is becoming more and more important in helping gynecologists identify the most frequent post vaginal delivery complications, facilitating an early diagnosis and a prompt treatment.

Conflict of interest disclosure

The authors declared no conflicts of interest.

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