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Computed Tomography / Tomodensitométrie

Computed Tomography Imaging of the Acute Pelvis in Females

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Abstract

Sonography is the primary imaging modality for the evaluation of pelvic pain in female patients, especially if gynaecological pathology is suspected. However, computed tomography (CT) is frequently used in patients who present to emergency departments (and elsewhere) with otherwise nonspecific abdominal and pelvic pain and may be the first imaging modality to demonstrate an acute gynaecological abnormality. Computed tomography can also be used prospectively in selected patients to further evaluate findings initially identified on sonography, although to reduce radiation exposure, magnetic resonance imaging is being used more frequently in this situation. The purpose of this article is to discuss the spectrum of gynaecological findings of the acute female pelvis that may be identified on CT by the emergency radiologist and by the general radiologist, with a brief review of the imaging literature of each specific diagnosis.

Résumé

L'échographie demeure la principale modalité d'imagerie pour évaluer les cas de douleurs pelviennes chez les femmes, particulièrement pour exclure une pathologie gynécologique. La tomodensitométrie (TDM) est toutefois fréquemment utilisée comme modalité de première intention, chez les patientes évaluées au service d'urgence (ou en externe) en raison de la non-spécificité des douleurs abdominales et pelviennes. Elle peut donc constituer la modalité d'imagerie initiale pour diagnostiquer les pathologies gynécologiques aiguës. On peut également recourir à la TDM prospectivement chez certaines patientes, afin de préciser les résultats de l'échographie initiale. Toutefois, à des fins de radioprotection, l'imagerie par résonance magnétique est favorisée dans ce type de situation. Le présent article vise à explorer les pathologies gynécologiques associées aux douleurs pelviennes chez la femme et pouvant être décelées à la TDM en radiologie d'urgence et en externe. Une brève analyse de la documentation sur l'imagerie des différents diagnostics est également présentée.

Key Words: Computed tomography; Pelvis; Women's imaging; Acute abdomen/pelvis; Emergency imaging; Ovarian torsion

Sonography (US) is the primary imaging modality for the evaluation of pelvic pain in female patients, especially if gynaecological pathology is suspected prospectively. Magnetic resonance imaging (MRI) is being increasingly used selectively in stable patients, when available, as a problem-solving tool, in pregnancy, or as a follow-up examination to reduce patient radiation exposure. However, computed tomography (CT) of the abdomen and pelvis is widely used as the initial cross-sectional imaging examination in the emergency setting of patients undergoing evaluation for otherwise nonspecific signs and symptoms associated with an acute abdomen. It is our frequent experience and the experience of other radiologists that a wide variety of gynaecological abnormalities are identified by using CT when such diagnoses are not prospectively expected (eg, in a woman with right lower quadrant pain and suspected appendicitis, who is then diagnosed with a gynaecological condition).

In recent years, CT has been increasingly used in the emergency setting for evaluation of the acute abdomen. Occasionally, CT will be performed after equivocal US or after US to further evaluate the findings (eg, in complex pelvic inflammatory disease (PID), when the findings extend beyond the field of view and/or involve bowel) [1]. However, when a diagnosis is established on the basis of an initial pelvic US, unless it does not correlate with the history and physical examination (ie, a small ovarian cyst, which does not explain the patient's significant pain, as per the assessment of the referring physician), CT should then be obtained only when truly indicated, to reduce radiation exposure.

Similarly, pelvic US is usually not needed after a definitive diagnosis is established based on initial CT (eg, a small

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simple or hemorrhagic ovarian cyst without any evidence for ovarian torsion is identified, and the rest of the examination is unremarkable, or if there is a definitive CT diagnosis of ovarian torsion or PID), or if the pelvic component of the CT is normal, and US, therefore, should also be used selectively [2–5]. Further imaging with US is warranted when the CT findings are equivocal (eg, in possible torsion) or for further evaluation of suspected endometrial abnormalities as well as in cases that are suspicious but not definitive for pelvic malignancy [2,4]. In a recent retrospective series of 70 patients, there was no patient in whom an abnormal US followed a completely normal CT examination of the pelvis, although there was increased radiologist confidence with the addition of US for less-experienced interpreters [2]. The purpose of this article is to review the CT imaging of the acute female pelvis, covering a spectrum of gynaecological disorders that may be identified and diagnosed by the radiologist, with a brief review of the imaging literature and accompanying case demonstrations.

CT Technique

As with all female patients of reproductive age, a human chorionic gonadotropin (HCG) level needs to be checked before CT, unless it is an absolute emergency (eg, in the trauma setting). Protocols vary, depending on patient's symptoms and institutional protocols and/or radiologist preference, but generally, routine intravenous contrast is administered, with portal venous phase images obtained. Oral contrast may be given in women with suspected appendicitis or other bowel disorders, although (paradoxically, because if gynaecological pathology is the initial clinical consideration, then pelvic US, not CT, should be performed first) for most gynaecological entities oral contrast would not be expected to have utility in most patients. Typically, 3-mm axial images as well as coronal reformations would be reconstructed. In very selected cases, delayed images of the pelvis may help to clarify the relationship of the urinary tract to gynaecological pathology which is identified on initial review of the CT images. Routine use of radiation dose reduction techniques are advocated, particularly in women of reproductive age and in female children.

Ovarian Torsion

Ovarian torsion (OT) is the result of rotation of the ovary on its axis. Arterial, venous, and lymphatic stasis results, and, then if untreated, infarction. OT affects prepubertal girls without a pre-existent ovarian lesion due to hypermobility of the adnexa, may rarely occur prenatally, and may also occur during pregnancy, as well as in patients undergoing treatment for infertility. Alternatively, an enlarged ovary due to a lead point, particularly a benign mass such as a large cyst or a teratoma (ie, a dermoid) also predisposes to OT. Spontaneous detorsion is relatively common, and the patient, therefore, may have a history of similar episodes of pain. The pain is often severe but may be nonspecific or lower grade. There is a palpable mass in approximately 50% of the patients, and there may be associated nausea, vomiting, and fever. The right ovary undergoes torsion more frequently than the left, because the space occupied by the sigmoid colon presumably ''protects'' the left ovary from twisting [6–8].

US with Doppler interrogation of the ovary is the imaging test of choice if OT is prospectively suspected (although establishing the US diagnosis of torsion can also be difficult). However, it has been our experience and the experience of other researchers that CT may be obtained first, and the radiologist must maintain a high index of suspicion for OT and must be able to make or at least suggest the diagnosis when appropriate [3,7,9–11]. CT and MRI are also useful if the US findings are indeterminate [7]. In a retrospective review of 28 patients with surgically-proven OT who underwent CT, the diagnosis of OT was mentioned in fewer than a third of the CT reports [3]. In another series, of 25 patients, OT was not correctly diagnosed based on initial US, but was suggested or diagnosed by using CT in 16 of the patients [12]. However, in that same series, which included a total of 58 cases of proven OT, overall, a correct diagnosis was made by using US in 71% of cases, whereas CT yielded a correct diagnosis in only 38% [12]. The inaccuracy reported for CT was at least partially attributed to the lack of radiologist awareness of the CT findings of OT [3].

The CT (and MRI) findings of OT include an enlarged, oedematous ovary (generally substantially, mean 9.5 cm in 1 series) with or without an identifiable cyst or mass, deviation of the uterus to the side of the torsion, rotation of an adnexal mass to the contralateral side of the pelvis, twisting of the fallopian tube and vascular pedicle, engorgement of the involved adnexal vessels, a thickened fallopian tube, a small amount of ascites, oedema of the

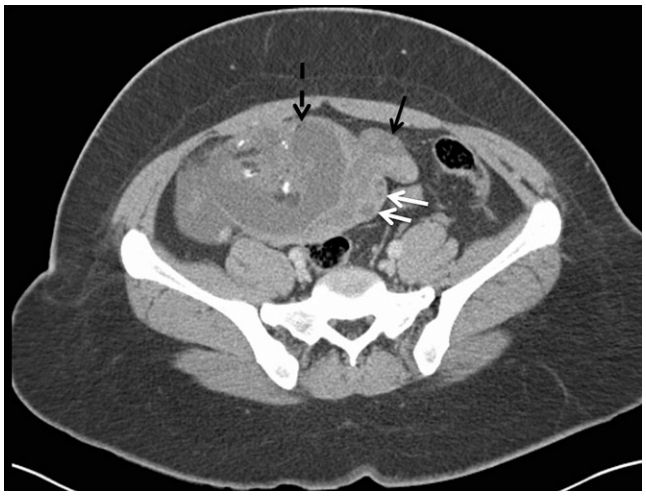

Figure 1. Left ovarian torsion related to a dermoid in a 23-year-old patient who presented with left lower quadrant pain. Axial contrast-enhanced computed tomography, revealing a 10-cm left ovarian mass that contains fat, soft tissue, and calcifications, which is diagnostic of a dermoid (black dashed arrow). There are multiple peripheral follicles (white arrows) in the left ovary. There is swelling of the left fallopian tube (black arrow), which may contain hemorrhage. There is associated right lower quadrant fluid as well as inflammatory changes of the fat adjacent to the left ovary.

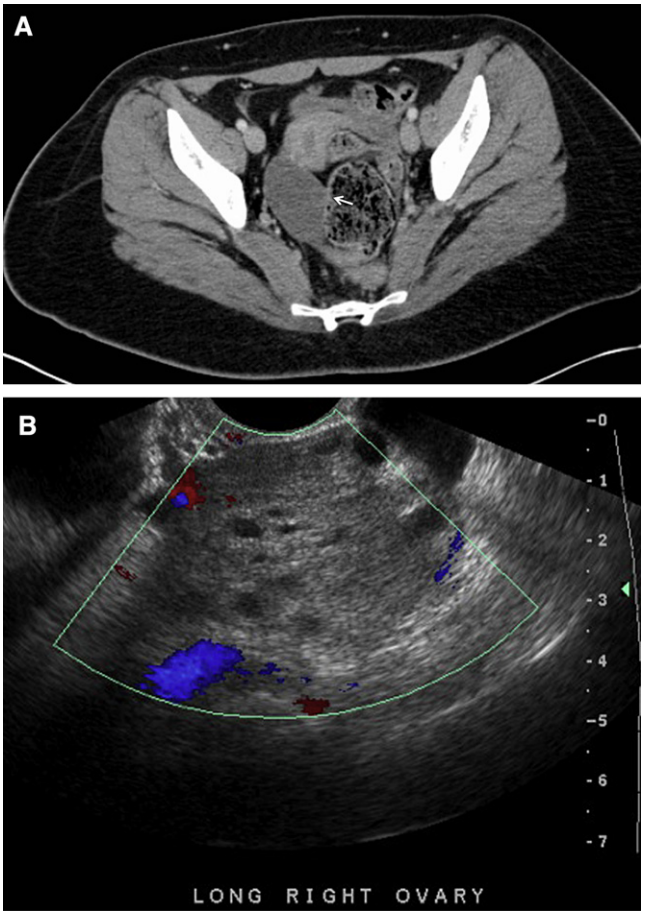

Figure 2. A 19-year-old patient with a history of polycystic ovarian syndrome, who presented with acute right lower quadrant pain. (A) Axial contrast-enhanced computed tomography, demonstrating an enlarged and relatively hypodense right ovary. There are several prominent follicles (eg, arrow) in the right ovary. (B) Subsequent transvaginal ultrasound, showing absent flow in an enlarged, heterogeneous right ovary that contains multiple predominantly peripheral follicles. Intraoperative findings confirmed torsion. This figure is available in colour online at http://carjonline.org/.

adjacent fat, and decreased ovarian enhancement (Figures 1–3) [3,6,7,9–15]. Heterogeneous minimal or absent ovarian enhancement on CT specifies progression from ischemia to infarction, as does ovarian hematoma (which may have a hematocrit level), and ovarian gas (the latter of which is rare) [1,9,16]. Prominent peripheral ovarian follicles, equivalent to what is seen on US, are often present and are specific to the diagnosis in the appropriate clinical and imaging setting when unilateral [11,13]. The twisted vascular pedicle may be best visualized on reformatted images [10]. Ipsilateral fallopian tube thickening and/or a twisted vascular pedicle are the most-specific CT findings for OT but are evident in only a minority of patients [6,12].

It has been our experience and the experience of other investigators [2] that emergency departments over order pelvic US for "rule out OT" after a negative CT or after a CT that shows an otherwise small and simple ovarian cyst or follicle. It should be noted that, in 1 series of 55 female patients who underwent both US and CT for an acute pelvis, there was no patient with a normal ovarian appearance on CT with subsequently proven OT [3]. OT has a relatively high rate of association with an underlying teratoma, and the resultant CT findings vary, depending on the degree of vascular compromise as well as the typical findings of a teratoma on which there are superimposed changes, including oedema of the teratoma wall and of the adjacent fat, along with other features of OT as described above (Figure 1) [17–19]. In a series of 14 torsed and 23 uncomplicated ovarian teratomas on CT, periovarian oedema and enlargement of the ipsilateral fallopian tube were most strongly associated with OT [19].

Rarely, sudden rupture (with or without torsion) of an ovarian teratoma can occur (the thick capsule is believed to be a barrier to rupture, unlike in ovarian cysts). This phenomenon is also associated with trauma, infection, and labor [20]. Patients may present acutely with chemical peritonitis or with chronic granulomatous peritonitis from chronic leakage. In acute rupture, there are fat-fluid levels in the peritoneal cavity, and, in chronic leakage, there are fatty peritoneal implants. In both presentations, there are signs of peritonitis and disruption of the shape of the teratoma [18,20,21].

Ovarian Cyst

Ovarian cysts or follicles are a very frequent cause of acute pelvic pain, with or without rupture, but, alternatively, such ovarian cysts are commonly incidentally identified on CT examinations performed for unrelated reasons. Although the pain related to rupture of an ovarian cyst or follicle is usually abrupt in onset, the cause may not be clear when the patient presents, and CT, therefore, may be performed rather than pelvic US. Most commonly due to a corpus luteal cyst or follicle but, sometimes due to a follicular cyst, they may have a simple or hemorrhagic appearance. Rupture is common, which leads to associated free pelvic fluid, which is usually relatively small in amount. Less commonly, there is associated intraperitoneal hemorrhage, which is usually self-limiting, but which rarely may cause hypotension and be potentially life threatening. Correlation must be made with an HCG level is not checked, because ectopic pregnancy can present with a similar clinical and CT picture, particularly if there is associated intraperitoneal hemorrhage [22,23].

On CT, a corpus luteum has a typical appearance, which presents as a relatively small cystic ovarian structure with a thickened, crenulated, and enhancing wall, which may be discontiguous or irregular [23–26]. With hemorrhagic cysts, a hematocrit level may be identified. If there is hemoperitoneum, then the underlying hemorrhagic cyst may or may not be evident, or an alternative diagnosis may be identified if there is no underlying cyst or ectopic pregnancy, yet hemoperitoneum is present on CT (Figure 4) [22]. Identification of active hemorrhage is very unusual but can occur, especially if there is an underlying bleeding disorder [27,28].

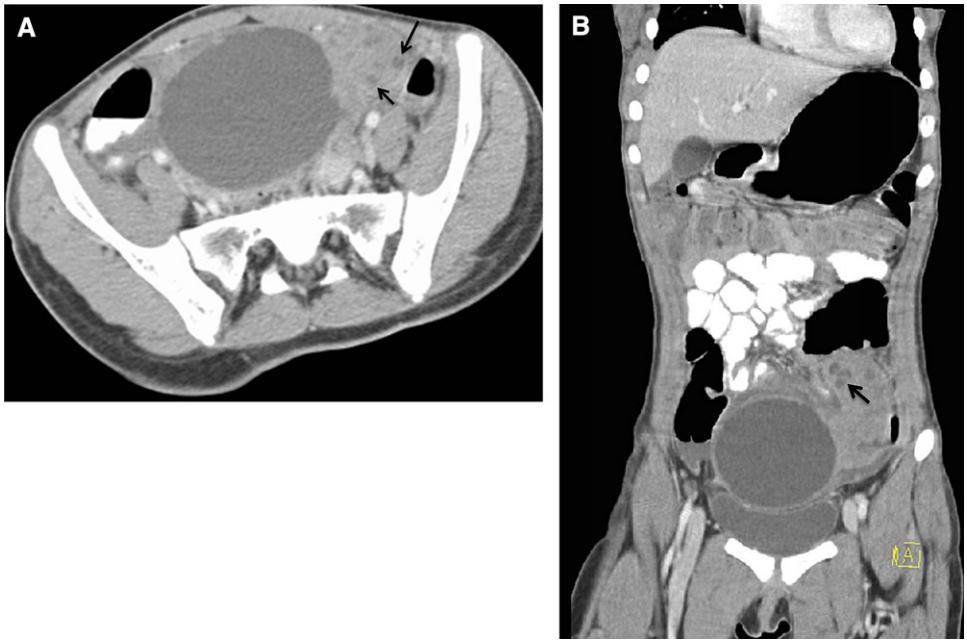

Figure 3. Left ovarian torsion related to a cyst in a 13-year-old patient with a 4-day history of abdominal pain. (A) Axial and (B) coronal contrast-enhanced computed tomography, showing an enlarged left ovary that contains an 8-cm simple cyst and multiple dilated follicles (black arrows).

Endometrioma

An endometrioma of the ovary-adnexal region may present with acute or subacute pain. Endometriosis involves the ovary in up to 80% of cases. Cross-sectional imaging is useful for identification of larger implants, but laparoscopy remains the test of choice for diagnosis and staging [29]. Hemorrhagic cysts can appear identical to otherwise simple ovarian endometriomas on CT in our experience (Figure 5). However, in a recent CT report, compared with functional ovarian cysts, ovarian endometriomas were significantly larger (70 vs 36 mm in maximal diameter), had a multilocular shape, and a thicker cyst wall [30]. Endometriomas may be multiple and/or bilateral in upward of 50% of patients, and there may or may not be visible extra-ovarian implants, although the presence of such findings is more specific than identification of a solitary hemorrhagic ovarian lesion, as is their persistence on follow-up imaging examinations, compared with hemorrhagic functional cysts [29,31,32]. Although relatively common, there are few reports to our knowledge of the CT appearance of adnexal endometriosis, but focal masses may be cystic, solid, or mixed [5,33]. Occasionally, endometriosis can simulate a malignancy, with irregular margins and invasion of the sigmoid, or other structures, and, occasionally, there is acute rupture of an endometrioma [5,34].

Ectopic Pregnancy

Risk factors for ectopic pregnancy include a history of a previous ectopic, a history of sexually transmitted disease, prior pelvic surgery, and an intrauterine device. Presentation is usually by the seventh week, although it is occasionally later [35]. Signs and symptoms include some combination of abnormal vaginal bleeding, pelvic pain (including cervical motion tenderness), and a palpable adnexal mass, although the clinical symptoms can be vague. Most commonly there is implantation in the ampullary portion of the fallopian tube, with a small minority implanting in the cervix; in the interstitial, isthmic, and fimbrial portions of the fallopian tube; in the ovary; or within the abdominal cavity [36]. Compared with US, CT has a very secondary role, but hemoperitoneum and/or an adnexal mass may be encountered on CT in an unanticipated ectopic pregnancy, in patients whom are not known to be pregnant (eg, with a false-negative urine pregnancy test, or if an HCG level is not checked) (Figure 6) [16,24,37]. CT shows a thickened sac-like structure or a fetus in the adnexa. There are few reports of the CT findings in intraperitoneal ectopic pregnancy to our knowledge [38], as well as rare reports of identifiable active hemorrhage related to complicated ectopic pregnancy [16,22,39,40].

Unexpected Intrauterine Pregnancy

Pregnancy may be encountered unexpectedly on CT, for example, if obtained emergently, particularly in a trauma patient, without checking an HCG level. There are understandably few reports on the CT findings in early pregnancy, whether normal or abnormal [26,37,39]. The radiologist should be suspicious regarding possible pregnancy if the endometrial cavity appears particularly enlarged or rounded, oval, or heterogeneous in a patient scanned emergently, and should then inquire as to the patient's HCG level. Eccentric dilatation of the myometrial

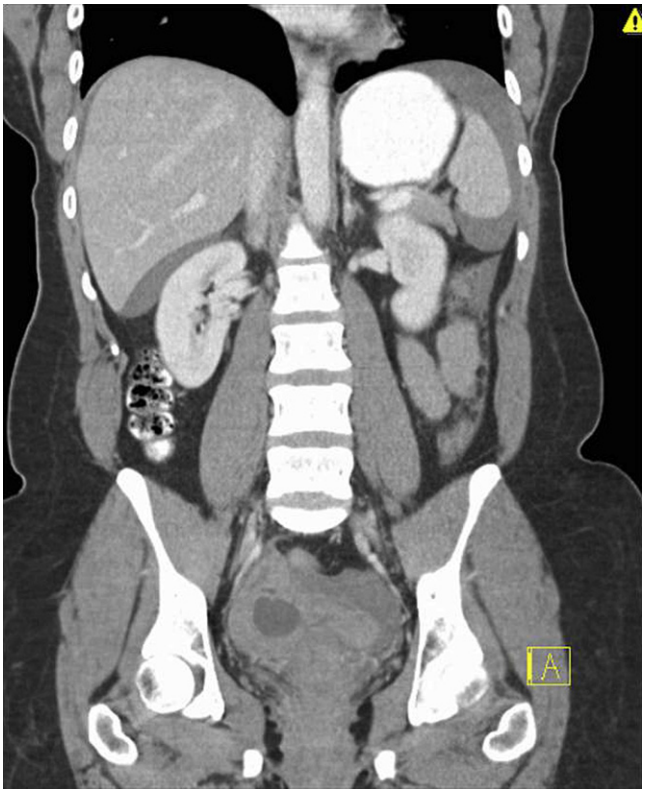

Figure 4. A 35-year-old patient with left-sided abdominal pain and nausea. Coronal contrast-enhanced computed tomography, showing a 2.5-cm homogeneous hypodense cyst in the right ovary and a moderate amount of hemoperitoneum (which is densest in the pelvis), which represents a ruptured ovarian cyst with associated hemorrhage. Active hemorrhage was not identified, and the patient was treated conservatively.

vessels and placental cotyledons with irregular enhancement can also be seen on CT in relatively early intrauterine pregnancy. The fetus presents as a subtle floating hyperdense focus in the amniotic cavity in the early second trimester [26].

Figure 5. A 40-year-old patient with severe lower abdominal pain. Axial contrast-enhanced computed tomography, demonstrating a 4.5-cm cystic mass in the left adnexa, just posterior to the bladder (black arrow, bladder), with layering dependent hyperdensity, which represents an endometrioma in this patient with known endometriosis.

Figure 6. Ectopic pregnancy in a 39-year-old patient with persistent vaginal bleeding, fever, abdominal pain, and leukocytosis. The patient was thought to have had a spontaneous abortion 2 weeks earlier but proved to have a ruptured ectopic pregnancy. Axial contrast-enhanced computed tomography, revealing a mildly enlarged, heterogeneous uterus with prominent vessels. There is hyperdense fluid surrounding the uterus. It is difficult to specifically identify an extrauterine gestation or an abnormal fallopian tube.

Ovarian Hyperstimulation

CT is valuable in the diagnosis and staging of patients with known or suspected gestational trophoblastic disease, although US should be the initial imaging examination. Occasionally, such patients present acutely and may undergo CT, in which the diagnosis is not suspected prospectively. Such patients may have associated ovarian hyperstimulation due to their very high HCG levels. Alternatively, ovarian hyperstimulation may be identified as a result of treatment for infertility or be related to other hormonally active tumours, in which case, again, the diagnosis is not suspected and the patient undergoes initial CT rather than US. Such patients may present with pain, nausea, vomiting, and abdominal distension. Findings on US and CT include ascites, pleural effusions, and substantial enlargement of both ovaries (as opposed to 1 ovary in torsion) with prominent peripheral follicles (Figure 7) [41].

PID

PID is common and has a broad spectrum of presentations, from subclinical to severe. Most cases result from ascending bacterial infection. There are a variety of causal and associated microorganisms. Patients present with pain, cervical motion tenderness, abnormal vaginal discharge and/or bleeding, dysuria, dyspareunia, nausea, and vomiting. There is fever and leukocytosis, and an elevated sedimentation rate, in most patients. Patients occasionally present when they are postmenopausal [39,42]. Signs and symptoms of uncomplicated infection are similar to those with complicated infection (ie, with tubo-ovarian abscess [TOA] and hydrosalpinx/pyosalpinx), and so US should be used initially as indicated to help make the distinction. Other complications of PID include

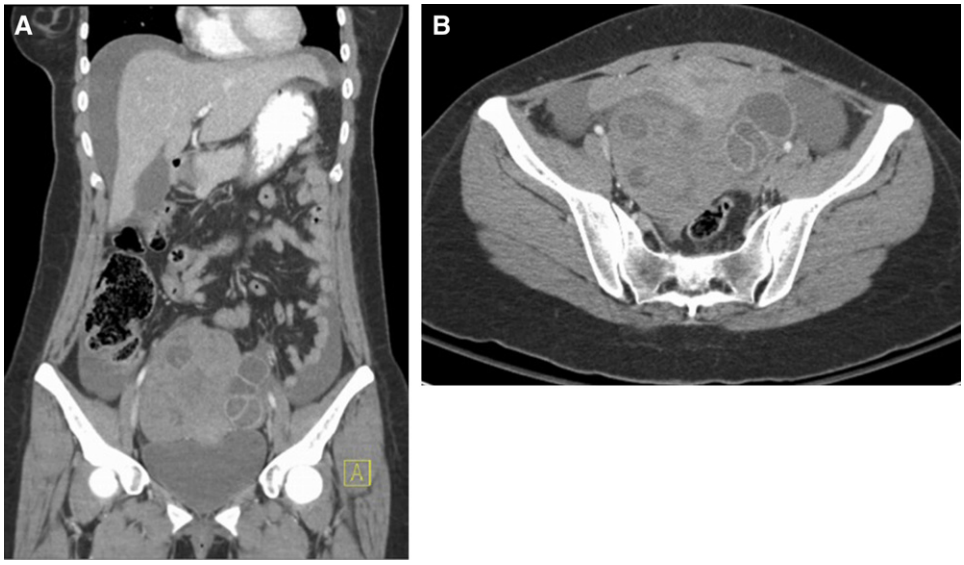

Figure 7. Ovarian hyperstimulation syndrome in a 29-year-old patient with right lower quadrant pain. (A) Coronal and (B) axial contrast-enhanced computed tomography, showing bilateral enlarged ovaries with multiple prominent follicles, left larger than right, as well as ascites. The uterus is displaced anteriorly.

infertility, chronic pain, and ectopic pregnancy as well as involvement of the gastrointestinal and urinary tracts [39,42,43]. The clinical presentation may be nonspecific, however, and, therefore, CT may be obtained first. In addition, CT and MRI can be used to image complicated cases of PID.

In earlier stages of PID, the CT findings can be normal or subtly abnormal (but, for this reason, may be even more difficult to identify on US compared with CT), including mild oedema of the pelvic fat adjacent to the uterosacral ligaments, mild salpingitis with inflammatory thickening of the fallopian tubes, and mild oophoritis with enlarged and abnormally enhancing ovaries with a polycystic appearance [1,31,42,44,45]. CT findings of later stages of PID include a greater degree of fallopian tube thickening and enhancement, TOA, hydrosalpinx/pyosalpinx, and involvement of adjacent organs, including the ureter and the large or small bowel (Figures 8 and 9) [43–46]. TOAs are thick-walled low-attenuation adnexal masses with thick septations, often associated with a serpiginous, dilated fallopian tube (ie, a hydrosalpinx/pyosalpinx). Internal gas bubbles are specific but unusual. In a review of 22 cases of TOA on CT, 73% were unilateral (in contrast to previous reports in which bilateral TOA was more common), 89% were multilocular, 59% were associated with bowel thickening, and 50% had a pyosalpinx. Uncommon findings in this series were ascites, para-aortic adenopathy, hydronephrosis, and gas formation [46].

Figure 8. Unilateral pyosalpinx in a 50-year-old patient with left lower quadrant pain and fever. Axial contrast-enhanced computed tomography, revealing a dilated, fluid-filled left fallopian tube with a thickened and enhancing wall. There are inflammatory changes of the adjacent fat.

In a recent series of 48 patients, the most specific CT finding of PID was thickening of the fallopian tube(s), with a specificity of >90%, whereas the most sensitive finding was mid pelvic fat stranding, seen in 60% of patients [47]. In another recent series of patients with TOA on CT, there was periovarian fat stranding in 58% and rectosigmoid thickening in 38% [48]. To differentiate TOA from abscesses related to other processes, anterior or inferior displacement of the round ligament was noted to be specific and was identified on CT in 82% of 22 patients in this latter series [48].

CT findings of endometritis related to PID are similar to those in postdelivery endometritis (except for the expected enlarged uterus and other associated normal postdelivery findings), with abnormal endometrial enhancement, fluid in the endometrial cavity, and, occasionally, gas. Cervicitis is identified on CT by an enlarged cervix with an abnormally enhancing endocervical canal. With Fitz-Hugh-Curtis syndrome, there is increased enhancement of the peripheral liver, stranding of the perihepatic fat, and the CT equivalent of ‘‘violin-string’’ adhesions. Findings are more evident on arterial-phase images [49,50]. In a series of 55 patients with Fitz-Hugh-Curtis syndrome imaged with CT, there was increased enhancement of the hepatic surface, particularly of the right anteroinferior hepatic edge, which correlated with other CT findings of PID, including oophoritis and mesenteric infiltration [51].

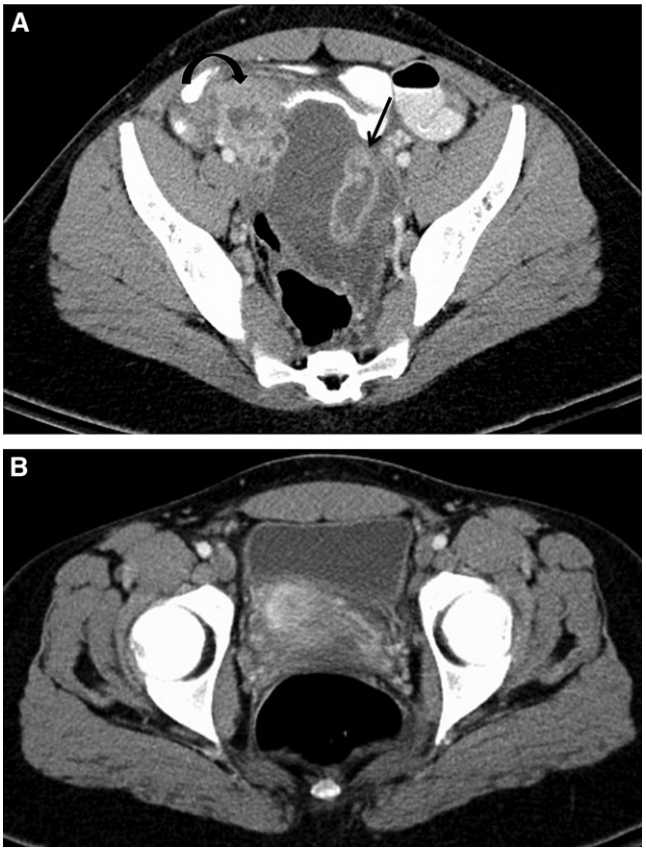

Figure 9. Bilateral tubo-ovarian abscesses/pyosalpinx and associated cervicitis in a 20-year-old patient with left lower quadrant pain, nausea, and vomiting. (A) Axial contrast-enhanced computed tomography (CECT), showing a tubular cystic mass in the left pelvis (black arrow), with a thickened and enhancing wall, which represents a TOA/pyosalpinx, which closely abuts the bladder. The right adnexa has a similar appearance but is larger, with a fluid-filled, tortuous fallopian tube, with a thickened and enhancing wall (curved black arrow), which cannot be separated from the right ovary. (B) Axial CECT, demonstrating a thickened and abnormally enhancing cervix, which represents cervicitis.

Pelvic actinomycosis, due to *Actinomyces israelli*, is a gram-positive fastidious bacteria and opportunistic pathogen that produces proteolytic enzymes, which is associated with intrauterine devices and PID. However, the presence of an intrauterine device and other findings of PID is not necessarily diagnostic for actinomycosis, nor does the absence of an intrauterine device exclude the specific diagnosis of actinomycosis. Actinomycosis produces a chronic, suppurative granulomatous process, with abscesses and fistulas, which may be confused with other diagnoses. In patients with PID related to actinomycosis, US shows complex pelvic findings that are typically better demonstrated on other cross-sectional imaging modalities [52]. Findings on CT, including an infiltrative aggressive complex pelvic mass with dense inhomogeneous contrast enhancement, in the correct clinical setting, should at least suggest the diagnosis [53,54], although definitive diagnosis requires microbiologic confirmation.

Endometritis and Ovarian Vein Thrombosis

Endometritis occurs in 3%-4% of patients after delivery, particularly after prolonged labor, premature rupture of membranes, or in association with retained products of conception, but is also associated with uterine instrumentation. Endometritis is a common cause of postpartum fever and occurs upward of 7 times more frequently after caesarean section compared with vaginal delivery. Patients present with pain over the uterus on palpation, fever, malaise, and vaginal discharge. CT findings (as on US) include thickening and fluid distension of the endometrial cavity, gas in the uterine cavity (which is much more specific if identified more than 10 days after delivery, although the clinical presentation is most often between the second and seventh postoperative days), associated inflammation of the parametrial soft tissues, and extrauterine abscesses. There may be increased enhancement of the endometrial cavity, which can also be seen in retained products of conception. Close correlation of the CT findings with the clinical presentation is necessary, because the CT findings may otherwise not be specific and overlap substantially with expected postpartum changes. CT, therefore, has been advised only for cases that are refractory to treatment and/or when ovarian vein thrombosis (OVT) is also suspected [16,39,43,55,56].

OVT occurs in upward of 1 in 600 deliveries and is usually related to bacterial seeding from endometritis [57]. OVT is also related to venous stasis, direct damage to the ovarian venous wall, and the hypercoagulable state of pregnancy. Clinical manifestations are variable, but include fever, as well as pelvic and back pain [57]. The right ovarian vein is reportedly much more frequently involved than the left (with a similar rationale as to why hydronephrosis usually has a right-sided predominance in pregnancy), but OVT is occasionally bilateral postpartum. As with endometritis, OVT is much more strongly associated with caesarean sections but less frequently can occur after vaginal delivery. In a different setting, OVT is common (and is frequently bilateral) after gynaecological surgery (particularly hysterectomy and oophorectomy), such patients are usually asymptomatic, and no specific therapy is typically required [58,59], in contrast to postdelivery OVT, in which antibiotics and, in some cases, anticoagulants are administered. There is a controversial association of postpartum OVT with pulmonary embolism, although we have identified a few such cases in our practice. There are other less-common etiologies of OVT, including other hypercoagulable states such as antiphospholipid antibody syndrome [60].

CT findings are those of any other thrombosed vein, with partial or completely occlusive low-density thrombus within the ovarian vein, which is present anterior to the psoas muscle and which may be accompanied by increased enhancement of the ovarian venous wall related to increased flow in the vasa vasorum. There may be inflammation of the perivenous fat as well as ascites (Figures 10 and 11) [57,61]. The findings may be subtle

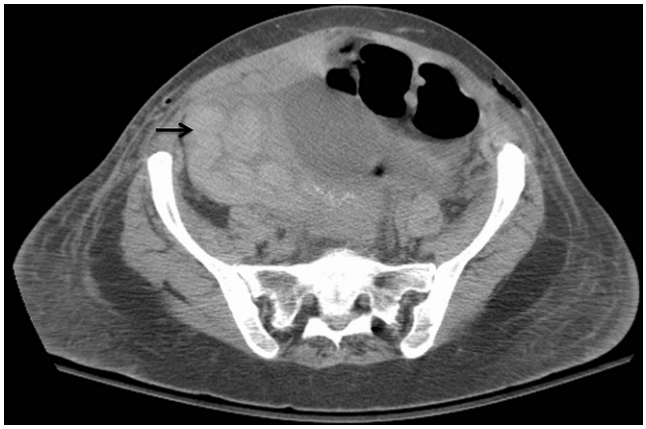

Figure 10. Right ovarian vein thrombosis in a 35-year-old patient after caesarean section and subtotal hysterectomy 7 days earlier, with ecchymosis and tachycardia. Axial computed tomography (which was performed without contrast to evaluate for hematoma because the patient's hematocrit level had decreased), demonstrating a markedly enlarged and tortuous thrombosed right ovarian vein (black arrow).

Figure 11. Right ovarian vein thrombosis in a 23-year-old patient, after vaginal delivery, with right lower quadrant pain. Axial contrast-enhanced computed tomography reveals a thrombosed, dilated right ovarian vein (black arrow) surrounded by substantial fat stranding.

and easily missed if not specifically searched for on CT and may also be difficult to differentiate from other abnormal tubular structures, including an abnormal appendix, a dilated ureter, a dilated ureter, PID (ie, a hydrosalpinx or pyosalpinx), and a thrombosed inferior mesenteric vein [39,48,56,57,61]. In contrast to many of the other pelvic entities discussed here, CT is the imaging modality of choice if OVT is specifically suspected. In a series of 12 cases of OVT identified on CT (of 64 patients prospectively imaged for suspected OVT), US was positive in only 6 [62].

Uterine Rupture

Uterine rupture is rare and potentially life threatening. It may follow a dilation and curettage, and also can occur before, during, or after delivery, especially in women with prior uterine surgery who then delivery vaginally, or it may be related to prolonged labor. Patients usually have sudden onset of severe pain. There are a handful of case reports of perforation of the uterine wall on CT [24,39,56,63–65]. Establishing the correct diagnosis can be difficult with any imaging modality, in our experience and based on the on the limited literature available on this topic, although MRI appears to be the best imaging modality for the diagnosis [55]. The uterus, especially at the lower uterine segment, appears disrupted at the caesarean section incision site, although rupture in women without prior uterine surgery usually occurs at the uterine body. Other imaging findings include associated hematoma in the broad ligament and hemoperitoneum (Figure 12) [55].

Gynaecological Neoplasms With Acute Presentation

Occasionally, patients with gynaecological neoplasms of varying types can present acutely, and the diagnosis will not be suspected clinically until CT is performed for otherwise nonspecific abdominal and/or pelvic pain (Figures 13 and 14) [4,40]. Concurrent symptoms may include abdominal pressure

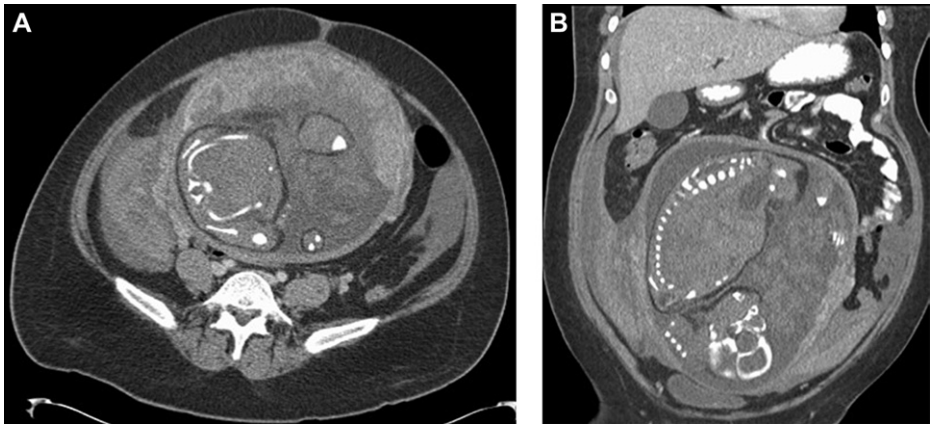

Figure 12. Uterine rupture in a 34-year-old patient with acute right lower quadrant pain after a failed attempt at a vaginal birth, after previous caesarean section. (A) Axial and (B) coronal contrast-enhanced computed tomography, demonstrating a relatively large amount of hemoperitoneum, particularly in the right pelvis, which proved to be related to uterine rupture at subsequent emergency caesarean section.

Figure 13. A 47-year-old patient with a family history of Lynch syndrome, who presented to the emergency department with abdominal pain and a palpable mass. Coronal contrast-enhanced computed tomography, demonstrating a large left ovarian complex cystic mass with a relatively thick wall, a few septations, and an inferiorly located heterogeneous soft-tissue component. There also is a small amount of ascites. After resection, the mass was found to be an ovarian cystadenocarcinoma.

from mass effect, urinary frequency, and early satiety [4]. As noted above, these include benign underlying ovarian neoplasms, such as cysts and teratomas, which can present with torsion (frankly malignant ovarian tumours are more often fixed and, therefore, rarely present with torsion) as well as the occasional ovarian carcinoma, uterine carcinoma, or gestational trophoblastic neoplasm, which presents acutely for a variety of reasons (ie, hemorrhage, abrupt onset of ascites, and necrosis) [4].

Complicated Uterine Leiomyomas

Because they are so common, leiomyomas, also called fibroids, are frequently identified incidentally on abdominal and pelvic CT examinations performed for unrelated reasons. Uncommonly, patients may present with acute pain related to fibroids due to degeneration, hemorrhage, torsion of a submucosal or subserosal fibroid, acute thrombosis of the fibroid's venous outflow, prolapse of a pedunculated submucosal fibroid, superinfection, or a combination of these [1,5,29]. Patients may also present with acute pelvic symptoms after uterine artery embolization for fibroids. US is the primary imaging examination, with MRI for further characterization [1], but CT may be the initial examination performed, a scenario that we have seen multiple times in our practice. Growth of fibroids, with subsequent complications, particularly degeneration, can occur during pregnancy and is also associated with oral contraceptives [1,66,67]. The patients may also have pelvic pressure, vaginal bleeding, fever, and elevation of the white blood cell count. The larger the leiomyoma, the greater the likelihood of further growth and then degeneration in pregnancy [67].

Figure 14. A 53-year-old patient with vaginal bleeding and a human chorionic gonadotropin level of >600,000U. Axial contrast-enhanced computed tomography, demonstrating an enlarged uterus with thickened, enhancing, heterogeneous myometrium (black arrows) and with multiple heterogeneous, partially hemorrhagic, masses (white arrows) that extended into the myometrium. The findings represent choriocarcinoma. A small amount of hyperdense fluid is seen in the endometrial cavity, which represents hemorrhage.

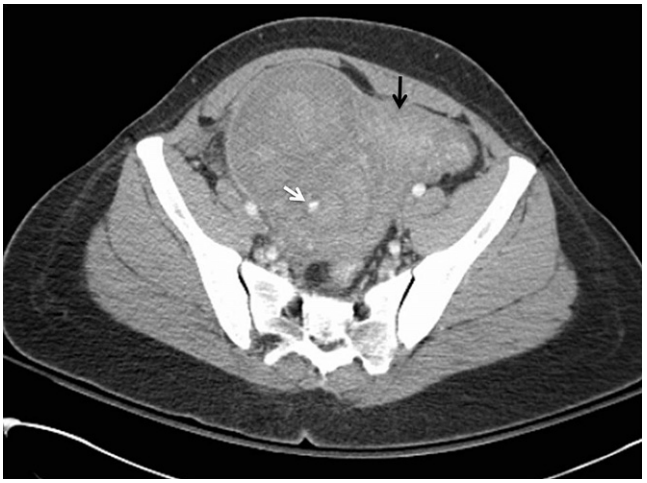

Figure 15. A 36-year-old patient with diffuse abdominal pain after recent vaginal delivery. Axial contrast-enhanced computed tomography, demonstrating a relatively large area of acute hemorrhage within the right lower uterine segment, displacing the rest of the uterus (black arrow) to the left. There is a small focus of active hemorrhage (white arrow) in the hematoma. The hematoma is separate from the endometrial stripe and is more likely related to bleeding into a necrotic lower uterine segment fibroid rather than traumatic bleeding from vaginal delivery.

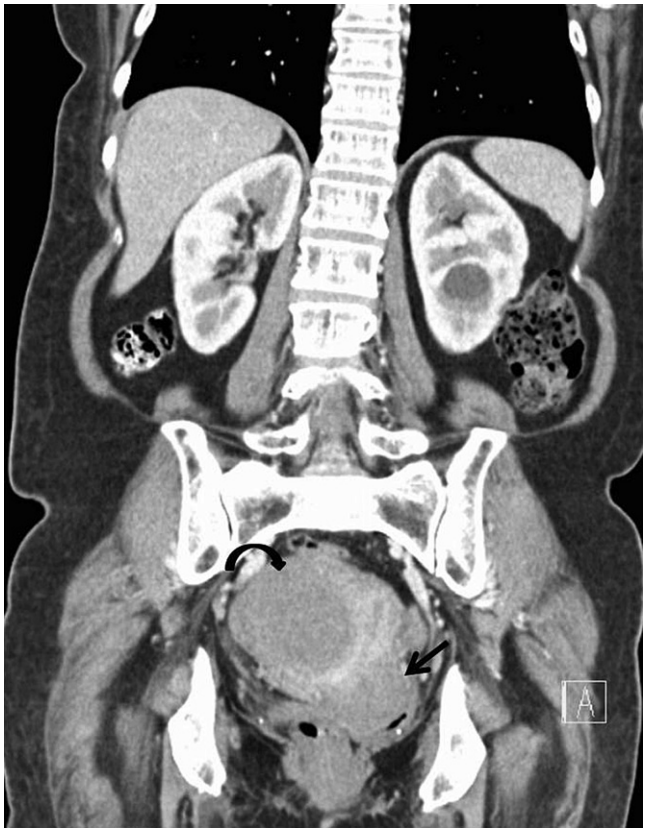

Figure 16. A 57-year-old patient with right lower quadrant pain. Coronal contrast-enhanced computed tomography, demonstrating an exophytic anterior uterine fibroid with diffuse low density, which represents hemorrhage and/or necrosis and/or degeneration (curved arrow). The fibroid has a broad interface with the main uterus (straight arrow).

CT findings of degenerated fibroids include varying degrees of liquefaction, which may also contain hemorrhage [5]. There typically is oedema around acutely infarcting and/or torsed fibroids. Infection is rare (without uterine artery embolization) but can occur in submucosal leiomyomas due to the more tenuous blood supply (Figures 15 and 16) [66]. Cervical prolapse of a fibroid is uncommon but has been more frequently reported recently, after uterine artery embolization (upward of 2.5% incidence). The patients present with pain, fullness, and vaginal bleeding. Infarction and/or superinfection can then occur [68]. The diagnosis is difficult to make by physical examination and US [69] but may be established by CT and particularly MRI as a prolapsing mass into the cervical region and/or vagina, which may have a ‘‘broccoli-like’’ appearance [29,68,70,71].

Conclusion

Although, for multiple reasons, particularly the absence of ionizing radiation and the detailed evaluation of the uterus and ovaries, US remains the imaging examination of choice when gynaecological pathology is specifically suspected in a female patient with acute abdominal and/or pelvic pain, CT is frequently performed as the initial examination of female patients in the emergency setting where such pathology is not initially suspected but is subsequently identified on the basis of the CT findings. In very selected cases, in which the US findings are indeterminate or the findings extend beyond the field of view, in selected cases in which CT is the imaging examination of choice (eg, suspected OVT), or in selected cases to follow-up the US findings, CT may be used as well. Radiologists, therefore, need to be familiar with all of these disorders and their CT appearances.

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