Abstract
Unlike ultrasound and magnetic resonance imaging (MRI), computed tomography (CT) is not generally indicated as the first line imaging technique in the study of female pelvic pathology. However, CT is often used to evaluate non-gynecological pelvic pathology, in the emergency department or in a follow-up context, in which the pelvic organs are encompassed. In these situations, the contrast enhancement pattern of the uterine body and cervix may be difficult to interpret and may simulate pathology, given the wide spectrum of enhancement patterns, anatomic variations and underlying pathology. In this article the authors review and illustrate uterine CT and MRI contrast enhancement patterns and possible pitfalls, in order to facilitate the differentiation of normal and pathological aspects of the uterus in CT.

Key-words
Uterine body; Uterine Cervix; Computed Tomography; Magnetic Resonance Imaging.

Introduction
Ultrasound is the first-line technique in the study of the female pelvis, given its easy access, reduced cost and the absence of ionizing radiation\(^1\). Magnetic resonance imaging is a complementary technique to ultrasound, essentially reserved for the study of indeterminate female pelvic lesions on ultrasound or CT scan. CT is not recommended as a first-line test in the assessment of the female pelvis, due to its low sensitivity and specificity, as well as the effects of ionizing radiation on the reproductive organs. Pelvic CT is performed for the study of various non-gynecological indications, in which the uterus and adnexal structures are encompassed. Familiarization with normal radiological aspects of internal genitals in CT prevents diagnostic errors and unnecessary exams. There is a broad spectrum of intravenous contrast enhancement patterns resulting from various factors that may sometimes mimic pathology\(^2,3\). Unlike most abdominal organs, which have already been characterized in different phases after intravenous contrast administration\(^4,5\), there are few studies on uterine contrast enhancement patterns on CT. These uterine contrast enhancement patterns have already been characterized by MRI after intravenous administration of gadolinium\(^3,6,7\), however they are not always consistent with those observed on CT.

1- Anatomical Fundamentals
Vascularization of the uterus is mainly performed by the uterine arteries, branches of the anterior division of the internal iliac arteries (Fig. 1). In the broad ligament, after crossing the ureter, the uterine arteries penetrate the myometrium at the isthmus level. Bilaterally, a branch of the uterine artery has an upward path in the myometrium, and afterwards in the thickness of the broad ligament, reaching the ovarian hilum, where it anastomoses with branches of the ipsilateral ovarian artery\(^8\). The other branch of the uterine artery shows a downward path, irrigating the cervix, where it anastomoses with branches of the vaginal artery, forming the azygos arteries located in the anterior and posterior wall of the vagina. Thus, the cervix has a double vascularization, through the uterine arteries and the vaginal arteries.
Several tortuous branches of the uterine artery penetrate into the thickness of the myometrium, dividing and distributing themselves circumferentially to form the
anterior and posterior arcuate arteries, which anastomose in the anterior and posterior midline with the contralateral branches, and give rise to arterioles that penetrate the endometrium. The aforementioned anastomoses of the uterine arteries and their branches with the ovarian and vaginal arteries allow a greater and alternative vascular supply of the uterus, associated with a lower risk for lesion with reduction of blood supply. Uterine arteries show a dynamic appearance, varying according to the phase of the menstrual cycle, increasing in length, caliber and tortuosity in the secretory phase and decreasing in the proliferative phase.

2 - Uterus Normal Contrast Enhancement Patterns at CT

Uterine Body
The morphology of the uterus is documented with better anatomical detail with MRI in the sequence T2, where it is possible to identify its three layers: the hyperintense endometrium, the junctional zone or hypointense internal myometrium, and the external myometrium with intermediate signal intensity (Fig. 2). The endometrium varies in thickness depending on hormonal stimulation and menstrual cycle stage. The junctional zone differs from the external myometrium, by the presence of cells with larger nucleus and smaller cytoplasm, giving it a lower signal intensity than the rest of the myometrium. The junctional zone should have a thickness between 2 and 8 mm. Differentiation between the uterine layers also depends on the hormonal activity status. In pre-menarche and menopausal women, the uterus is small, with undifferentiated uterine regions, resulting from the reduced serum estrogen levels. During pregnancy, the junctional zone becomes more hyperintense, reducing the differentiation of the uterine layers characteristic of the non-pregnant uterus at fertile age. Six months after delivery it is again possible to identify the usual anatomy and layers that constitute the uterus.

The presentation of the uterus in the dynamic MRI study is variable and depends on the acquisition phase after intravenous contrast administration. Usually, the myometrium is homogeneous and hyperintense in the arterial and venous phase, while the endometrium enhances later and slowly, showing hypointensity compared to the myometrium (Fig. 3).

On CT without intravenous contrast, the uterus is uniformly hypodense, with a slightly more hypodense central zone corresponding to the endometrium. There is little published literature about uterus contrast enhancement patterns on CT. Kaur et al reported three types of intravenous uterine contrast enhancement patterns on CT: type 1, thin or thick subendometrial enhancement with or without enhancement by the external myometrium, observed at 30 to 120 seconds, common at childbearing age (Fig. 4-7); type 2, progressive enhancement of the external...
myometrium with homogenization of all myometrium or diffuse enhancement, without subendometrial enhancement, observed during fertile age and menopause (Figures 4 and 8); and type 3, mild and diffuse enhancement, essentially visualized at menopause (Figures 4 and 9). Kaur et al. also verified that type 1 enhancement was transient and had diffuse enhancement of the myometrium in the late phases. Yitta et al.\(^{13}\) described a fourth heterogeneous and multifocal enhancement pattern of the entire myometrium (Fig. 4 and 10).

The etiologies of this diversity of intravenous contrast enhancement patterns by the uterus remain to be determined; however, age, menstrual status and parity are possible conditioning factors.

Kaur et al. established the following explanations for uterine enhancement patterns: type 1, the thin layer of subendometrial enhancement could correspond to the junction of the basal layer of the endometrium with the adjacent myometrium, and the thick layer of subendometrial enhancement would consist of the junctional zone\(^{18}\). The type 2 enhancement pattern may be related to myometrial vascularization, which is hyperintense in T2 MRI, corresponding to the higher number of smooth muscle cells and abundant microcirculation\(^2\). The slight to moderate type 3 enhancement pattern, may be related to decreased muscle mass and atheromatous changes\(^2\).

CT shows a low sensitivity in the assessment of endometrial thickness, frequently overestimating it, being a common indication for complementary evaluation by ultrasound\(^{19,20}\).

The differential diagnosis of endometrial changes is difficult by CT, namely late endometrial enhancement with non-pure fluid in the endometrial cavity, pyometra or hematometra\(^{19}\).

**Uterine Cervix**

MR T2-weighted images allows to distinguish with good resolution and detail the four layers that make up the cervix: the central zone of the cervix with mucus that is hyperintense; the endocervix with its mucous folds which is also hyperintense; the inner fibromuscular layer of the hypointense stroma, which is in continuity with the junctional zone of the uterine body; and the external muscular layer of the stroma of intermediate intensity, which continues with

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**Figure 3** – Sagittal MRI pelvic T2 (left image) and sagittal dynamic study after intravenous administration of gadolinium sagittal T1 with fat saturation at 30, 60 and 80 seconds (the second to fourth images, respectively) show the normal presentation of the body and cervix. Throughout the dynamic study, the myometrium is presented hyperintense, while the endometrium and junctional zone, which have relatively hypointense at 30 and 60 seconds, show progressive enhancement over time. The endocervix enhances quickly, while the cervical stroma enhances gradually.

**Figure 4** – Illustration of uterine enhancement patterns of intravenous contrast CT.

**Figure 5** – Follow-up CT of a patient with a history of cutaneous lymphoma. Axial plane (a) and sagittal plane reconstruction (b) in portal venous phase (70 seconds) show a standard subendometrial enhancement pattern type 1, with fine linear contrast enhancement by myometrium (arrows) externally delimiting the endometrial cavity (asterisk).
Figure 6 – Resectability assessment CT for a mixed left adnexal tumor in a 41-year-old patient. Axial plane (a) and coronal plane reconstruction (b) obtained at portal venous phase (70 seconds) show a standard enhancement pattern type 1 thick subendometrial pattern, with enhancing myometrium contrast band (arrows) externally delineating the endometrium (asterisk). (a) shows a left retro-uterine adnexal tumor surpassing the midline (T), the right ovary (O) unchanged.

Figure 7 – Entero-CT of a 51-years-old patient with a suspected inflammatory small bowel disease. Axial plane (a) and sagittal (b) and coronal (c) reconstructions obtained at portal venous phase (for 45 seconds), show a standard type 1 capture with contrast uptake in thin subendometrial band delimiting the endometrial cavity (arrow) representative of the junctional zone and a thin outer peripheral uptake subserosal myometrium (triangle) delineating internal serosa.

Figure 8 – Pelvic CT in the initial evaluation of an adnexal right lesion (T) of a 49-years-old patient. Sagittal (a) and coronal (b) reconstructions obtained at portal venous phase (70 seconds) show a standard enhancement pattern type 2 with normal diffuse uptake of contrast by myometrium. (B) Bladder.

Figure 9 – Follow-up CT of a 89-years-old patient with history of malignant cutaneous melanoma. Axial plane (a) and sagittal plane reconstruction (b), at portal venous phase (70 seconds), show a standard enhancement pattern type 3, with mild, diffuse and homogeneous uptake of myometrium by contrast, limiting the endometrial cavity (asterisk).
the external myometrium (Fig. 2)\textsuperscript{6,7,21}. On dynamic MRI the endocervix presents a fast enhancement, as opposed to the gradually enhancing cervical stroma (Fig. 3)\textsuperscript{21,22}. As the uterine body, the CT contrast enhancement patterns of the uterine cervix are identical to those seen on MRI. A stratified enhancement pattern of the cervix layers is observed in the uterine body enhancement patterns 1 and 2 at CT, but not in type 3 pattern\textsuperscript{2}. The cervix stratified enhancement pattern at CT is typically characterized by low intense enhancement in the fibromuscular stroma surrounding an intense circumferential central enhancement (probably related to the central predominance of mucous glands)\textsuperscript{2}. The external fibromuscular layer of the stroma exhibits a stronger contrast enhancement than the inner fibromuscular layer, but less distinct than the central cervical mucosal layer. This contrast enhancement pattern at CT gives a target morphology on axial images (Fig. 11). The lesser enhancement of the internal fibromuscular layer of the stroma can be justified by the greater number of fibroblasts and muscle cells, which may be responsible for their relative hypodensity compared to the external layer\textsuperscript{21,22}. The cervix presents a diffusely lower contrast enhancement compared to the uterine body (Fig. 12), establishing a well-defined and regular boundary between the two, which may be due to the greater amount of fibrous tissue in the cervix.

2.1 - Factors Influencing the Contrast Enhancement Patterns of the Uterus at CT

Technical factors and specificities of the examinee may contribute to this variety of uterus enhancement patterns at CT. The rate of administration of intravenous contrast and cardiac output may influence the uterine body and cervix enhancement patterns. Different contrast enhancement patterns by the uterus may be identified in different vascular phases on the same CT scan\textsuperscript{2}, and may initially present a type 1 pattern and in a late phase a type 2 pattern. The enhancement pattern may also be diffuse at an early stage and present a washout in a late phase. Anatomic variants and vascular variations, may contribute to the different types of uterine enhancement. More studies are necessary to better characterize these factors on uterus contrast enhancement patterns at CT.
3 - Pathological Patterns of Uterus Contrast Enhancement at CT

Nabothian Cysts
Nabothian cysts are benign and correspond to retention cysts of the cervix, probably resulting from chronic inflammation. They are frequently asymptomatic and accidentally detected at CT. They are well-defined lesions of variable size, with water density, showing no contrast enhancement or peripheral or ring enhancement. Agglomerates may occur. In the axial CT images, they can sometimes simulate distension of the cervical canal filled with liquid, but in the sagittal and coronal planes they appear as well defined cystic lesions and distinct from the cervical canal, which presents intense enhancement.

Adenomyosis
Adenomyosis is a benign and relatively common entity in which there is ectopic endometrial tissue in the myometrium, affecting women at reproductive age. At CT with intravenous contrast, adenomyosis may present heterogeneous enhancement mimicking a uterus after delivery. Wood led et al described the radiological characteristics adenomyosis at CT, which are: enlarged uterus, thickening of the inner myometrium corresponding to the junctional zone, and myometrial cysts with a diameter of less than 1 cm (Fig. 13).

Infection
Cervicitis is a clinical diagnosis; however, radiological findings at CT, such as enlargement of the cervix, parametria densification, prominence of vascularization, increased cervical contrast enhancement, mucosal irregularities and the presence of gas bubbles (Fig. 14), may suggest its diagnosis. Findings of infection extension, such as rectal wall thickening and enhancement, or other aspects visualized in pelvic inflammatory disease, may also help in the diagnosis.

Malignancy
Uterine cervix may simulate pathology at CT due to its orientation and its different contrast enhancement compared to the body of the uterus. The evaluation of sagittal and coronal reformating often helps in the interpretation of these findings. Identification of the cervical canal and its continuity with the endometrium can be very useful in the identification of normal cervix, as well as the presence of a well-defined line limiting the myometrium with marked contrast enhancement as opposed to the lower enhancement of the cervix. The cervical canal must not be

![Figure 13](image1.png)

**Figure 13** – CT of a 58-years-old patient recently diagnosed with a follicular lymphoma. Sagittal plane reconstruction (a) at portal venous phase (70 seconds), shows an enlarged uterus with the uterine fundus located above the promontory of sacrum, showing thickening of the junctional zone (J) and myometrial cysts (arrow). These findings were confirmed by ultrasound with transvaginal approach, where the identified feature presentation “rain shower” (b) aspects consistent with adenomyosis, leiomyoma is documenting even earlier intramural.

![Figure 14](image2.png)

**Figure 14** – Acute cervicitis in a 45-years-old woman with a diagnosis of Crohn’s disease and complaints of vaginal discharge. CT performed in portal venous phase (70 seconds), at axial plane (a) and the reconstructions in the sagittal (b) and coronal (c), show increased dimensions of the cervix (C), demonstrating increased uptake of contrast, difficult individualization of endocervix, with decreased density difference from the myometrium (M) and of the line attenuation delimiting the neck and body of the uterus, associated with the densification of the surrounding fat planes (arrow) and bilateral hydrosalpinx (asterisk).
erased nor obliterated. A lesion of the cervix can obliterate the cervical canal and result in distension of the endometrial cavity. The subendometrial type 1 enhancement pattern may simulate endometrial pathology, when the radiologist is not familiar with the uterus enhancement patterns at CT. The interruption or irregularity of the uniform enhancement of the sub-endometrial region, the presence of myometrial or cervical invasion, or endometrial cavity dilatation (Figure 15 and 16), suggest underlying pathology.

Iatrogenic
Patients subject to previous pelvic radiotherapy due to urogenital, digestive or other carcinomas may have atrophy of the external cervical os, more common in the menopausal phase, conditioning accumulation of contents and distension of the cervical canal and upstream endometrial cavity (Fig. 17), which can simulate pathology. The correct diagnosis is made with the clinical history.

Uterus After Childbirth
CT can be used after childbirth, particularly in the study of unexplained fever and unspecific abdominal pain. The postpartum uterus may simulate pathology, and the clinical history as well as familiarization with the tomographic features of the uterus after delivery may guide towards the

![Figure 15](image15.png)  
Figure 15 – Cervical squamous cell carcinoma of a 42-years-old woman. CT axial plane in the portal venous phase (at 70 seconds) shows loss of normal contrast uptake by the cervix (usually homogeneous and smaller in relation to the endometrium), as well as loss of the regular uptake of the endocervix, visualizing uptake (complete arrow), with loss of the regular line delimiting the hypodensity of the uterine cervix and the hyperdensity of the uterine body (incomplete arrow), and the presence of irregular and ill-defined endocervix.

![Figure 16](image16.png)  
Figure 16 – Mixed endometrial adenocarcinoma of the endometrioid and serous nature in a 74-years-old woman. Sagittal (a) and coronal (b) CT reconstructions performed in the portal venous phase (at 70 seconds), show the homogenous and diffuse (asterisk) type 2 myometrial uptake pattern, interrupted in the posterior slope and on the left side of the uterine body and fundus by a tumor with soft tissue density and irregular borders (arrows), which invades the myometrium at this level. This tumor also extends to the endocervix and cervical stroma (triangle).

![Figure 17](image17.png)  
Figure 17 – Status after neoadjuvant chemoradiotherapy and surgery for a rectal carcinoma in a 73-years-old woman. CT performed in the portal venous phase (at 70 seconds) with reconstruction in the sagittal plane (a) and in the axial plane (b), show distension of the cervical canal (C) with water density, as well as less accentuated distension of endometrial cavity (asterisk), resulting from iatrogenic atrophy of the external os of the cervical canal (arrow) to radogenic therapy. The radiological aspects favoring this diagnosis are the presence of vaginal air (triangle) immediately downstream to the external orifice of the cervical canal and the enhancement of the cervical mucosa that covers the cystic “structure”, as well as the clinical history. CT findings were confirmed by ultrasound (c).
correct diagnosis. Typically, the postpartum uterus is enlarged, with a distended endometrial cavity for approximately 6 to 8 weeks. The site of placenta implantation may demonstrate defects of the myometrium and increased contrast enhancement. Prominent vessels may also be visualized in myometrial thickness. The hysterotomy scar may be irregular and hypodense, with lower contrast enhancement than the adjacent myometrium. The presence of intrauterine air may be a normal finding in the first weeks after delivery, even in the absence of infection. Intrauterine clots are also likely to occur in the immediate postpartum period. The presence of intraperitoneal air is normal after a caesarean section, however it is pathological in a vaginal delivery.

4 - Pitfalls

Endometrial thickness can easily be exaggerated in axial and coronal at CT images, especially when the uterus is positioned in anteversion or retroversion, in which the endometrium presents an oblique orientation and is often overestimated.

Endometrial evaluation at CT should be performed in sagittal reconstructions.

Conclusion

CT is a technique with low diagnostic acuity in uterine evaluation, however the uterus is frequently evaluated on CT performed for non-gynecological indications. Thus, it is important to be familiar with the different forms of presentation of the uterus in this method, which are sometimes difficult to interpret.

The uterine body and cervix present dynamic and diversified enhancement pattern at CT, depending on several factors, such as age, menstrual status and acquisition phase.

In the presence of morphological alterations or atypical contrast enhancement of the uterus at CT, a directed study by ultrasound or MRI should be suggested, since these are the election techniques in the evaluation of internal genital organs.

References


