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Gynecological pelvic infection: What is the role of imaging?

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Pelvic infection is a common ailment, since it affects one million women annually in the United States, and its treatment remains costly. The treatment of choice in forms that are detected early consists of a simple, properly implemented antibiotic regimen. But when therapy is delayed or omitted, an acute infection can become the source of multiple secondary complications: 30% of cases of infertility and 50% of cases of ectopic pregnancy (EP) can be attributed to a prior episode of tubal inflammation.

Pelvic infections are usually divided into two categories:

- pelvic inflammatory disease encompasses all upper infectious diseases such as salpingitis, endometritis, hydrosalpinx, pyosalpinx, and tubo-ovarian abscess;

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• infections occurring in certain particular contexts: During the post-partum or post-abortion period, when the clinical diagnosis is easy and imaging plays a limited role. More rarely, it can be secondary to a surgical procedure or reflect the spread of infection from other organs to the genital organs (appendicitis, diverticulitis, tuberculosis). In the two latter situations, the imaging signs and symptoms of pelvic infection have nothing specific. They will therefore not be discussed in detail in this article.

Pelvic inflammatory disease (PID) encompasses all upper genital infections (uterine, tubal, and ovarian). This disease can be caused by many microorganisms. The main ones, in order of frequency, are: Chlamydia trachomatis, Gram-negative bacteria, mycoplasma, and Neisseria gonorrhoea. In more than 50% of cases, there is a polymicrobial infection. There are multiple routes of dissemination. Most often, there is an ascending infection stemming from a lower genital infection due to diffusion of endometrial desquamation fluid into the peritoneum via the fallopian tubes. This occurs during the post-menstrual period and involves microorganisms such as gonococcus. Dissemination can occur via the lymphatic system (infection due to intrauterine device [IUD]) or by hematogenous spreading (tuberculosis) [1]. All conditions that affect the upper genital tract are grouped into a common entity (PID), since they are part of a clinical continuum. For the sake of clarity, we will split up the imaging features for each stage of infection, however, in daily practice, there is a gradual progression with no real demarcation between each section that we are going to discuss.

Acute stage of PID

The infection starts in the endometrium — endometritis, which has no specific imaging features (endometrial thickening ± intra-endometrial effusion). Acute inflammation then affects a fallopian tube in the form of salpingitis, which often becomes bilateral or abscesses, in the form of pyosalpinx. Inflammation may then spread to the ovary and become tubo-ovarian complex, where the ovary and fallopian tube are still separate, or ultimately progress to a true tubo-ovarian abscess. Depending on the stage of progression at the time of diagnosis, the patient may undergo medical or surgical treatment, which may provide resolution of the symptoms. If treatment is insufficient or nonexistent, the infection may become chronic and cause sequelae, such as hydroosalpinx or peritoneal inclusion pseudocyst. Thirty percent of cases of infertility and 50% of cases of EP can be attributed to a prior episode of tubal inflammation [2].

Clinical aspect

The diagnosis of pelvic infection is most often made clinically, based on a combination of pelvic pain and fever, and possibly a foul discharge. Laboratory signs include a combination of hyperleukocytosis and elevated CRP. But in 20% of cases, patients with a pelvic infection have a normal leukocyte count and are afebrile or apyretic [3]. When there is a combination of pain, fever, and foul discharge, a diagnosis of salpingitis is suggested and antibiotic therapy is initiated. The patient is referred to radiology in two very different circumstances:

• either the patient has no specific symptoms and is seen for pelvic pain of undetermined origin (or does not respond to properly administered antibiotic therapy) and the radiologist must make a diagnosis in the acute stage of infection based on acute pelvic pain. The differential diagnoses are then appendicitis, urinary tract infections, complications of a hemorrhagic luteal cyst;
• or the patient is referred some time after the infectious episode, which may have gone unnoticed, and the patient presents with an undetermined pelvic mass that needs to be characterized, and the challenge in that situation is not to confuse it with ovarian cancer (Fig. 1).

If a diagnosis of pelvic inflammatory disease is clinically suspected, the definitive diagnosis is based on direct visualization of the infected areas during laparoscopy and on bacteriological specimens [1]. Laparoscopy is still an invasive and costly procedure, requiring that the patient be hospitalized. In the acute stage, the surgical procedure may be difficult, due to numerous adhesions, and responsible for surgical wounds, which are a source of secondary complications. It should therefore be reserved for difficult cases or when the outcome is not favorable with antibiotic therapy. Imaging constitutes a noninvasive approach that is increasingly often an option for gynecologists. It limits the number of exploratory laparoscopies performed with good diagnostic reliability. The MRI and ultrasound have sensitivity of 95 and 81%, specificity of 89 and 78%, and diagnostic accuracy of 93 and 80%, respectively [4].

Figure 1. Differential diagnosis between peritoneal inclusion pseudocyst (at left) and ovarian cancer (at right).
Endovaginal ultrasound

Among the imaging tests, the one that is in a direct continuum with the clinical examination is the endovaginal pelvic ultrasound with Doppler. It most often makes it possible to make a diagnosis of the lesion, perform disease staging, and rule out a gastrointestinal etiology for the symptoms. In addition, it makes it possible to monitor progression during treatment.

The diagnosis is suspected based on two cardinal signs, which are the bilateral nature and tubular shape of the masses discovered on the ultrasound (Fig. 2). The normal diameter of a fallopian tube should not exceed 4 mm, and usually "a visible tube is a suspicious tube" [5]. The basic ultrasound signs and symptoms of pelvic inflammatory disease were described by Timor-Trisch et al. [6] and are based on a combination of abnormal margins and adnexal walls, assessment of possible extension to the ovaries and existence of intrapelvic effusion.

On the ultrasound, inflammation manifests as a mass with blurred margins, with a continuum from the wall of a hypoechoic adnexal mass with spiculation in the fat related to infiltration of the adjacent subperitoneal fat (Fig. 3). In addition to abnormal margins, Timor-Trisch et al. recommend looking for inflammatory abnormalities affecting the tubal cilia. The tubal cilia thicken due to inflammation and are visualized according to different aspects depending on the angle of incidence of the probe. When the probe is positioned in the plane longitudinal to the tube, the tubal cilia appear in the form of incomplete septa with varying degrees of thickness depending on the degree of inflammation. When the probe is positioned in a plane perpendicular to the axis of the tube, the cilia have different appearances described in the literature, such as the cogwheel sign or beads on a string sign. That appearance can be misleading when the cilia are very thick and where they can be difficult to distinguish from vegetation when there is no acute context (Fig. 4).

Inflammation creates thickening of the tubal cilia, but also the wall of the fallopian tube. The limit of 5 mm of thickness was described by Timor-Trisch et al. as pathological. On the ultrasound, the fallopian tube has a thick, echogenic wall associated with edema, which is entirely nonspecific. According to the data in the literature, its content has a variable signal [7]. It may be totally anechoic, echoic (suggesting

Figure 2. Bilateral pyosalpinx. The tubular and bilateral nature is suggestive of pelvic inflammatory disease.

Figure 3. The infiltration of the subperitoneal fat, in the form of hypoechogenic spicula (arrows), is a sonographic sign suggestive of pelvic inflammatory disease.

Figure 4. Thickening of the tubal cilia on the longitudinal section (at left) and the cross-section (at right) relative to the axis of the fallopian tube. On the cross-section, the appearance of the cilia is called beads on a string. This sign may be confused with vegetation. The dynamic nature of the ultrasound facilitates the diagnosis. The tubal walls are also abnormally thickened (> 5 mm) and their diameter is greater than 2 cm.
the presence of pus), or show an air-fluid level, which is pathognomonic of pyosalpinx. It may be difficult to distinguish this from hematosalpinx of a different etiology, e.g., EP, in a context of acute pelvic pain. The possibility of an infectious lesion should always be considered with this type of image after a negative beta-hCG assay.

A tubal infection is rarely isolated. Tubal infection very quickly extends to the ovary and three stages of progression can be identified on the ultrasound: In the first, the ovary is not involved, and this is all the easier to assess when it contains one or more visible follicular formations. In the second, there is ovarian involvement, resulting in juxtaposition of the diseased tube and the ovary, but the two structures are still identifiable on the ultrasound. This stage of progression is called tubo-ovarian complex. The ovary is often infected in the form of oophoritis, which results in an increase in size and loss of corticomедullary differentiation [8]. If the ovarian involvement is such that these two structures merge and can no longer be identified, there is a tubo-ovarian abscess (Fig. 5). At this stage, the main problem is the differential diagnosis, since there is really no longer a tubular structure separate from the ovary to indicate tubal disease. When such a lesion is discovered in the chronic stage, it presents as a heterogeneous echoic mass, which may be voluminous; the tubal cilia can be interpreted as very vascularized vegetation on the Doppler flow study due to inflammation and may be mistaken for invasive malignancies. This diagnostic error can be very deleterious to the patient, who may be subjected to exploratory surgery, which, in a context of infection, can be the source of numerous complications due to adhesions. Such surgery may wrongly lead to an oophorectomy, which is also very deleterious, particularly in young patients. Finally, intrapelvic effusion is often found. Depending on the stage of progress, it may have varying degrees of echogenicity. When the effusion is periampullary, the hypervascular infundibulum can be visualized on the Doppler flow study. This isolated sign is totally nonspecific and is seen in inflammatory gastrointestinal diseases as well as in malignant ovarian disease. The presence of adhesions within the effusion is a sign that points toward a diagnosis of infection.

**CT scan and MRI**

The ultrasound can sometimes resolve this problem; in most cases, however, when there is diagnostic difficulty, two diagnostic tests should be considered: the CT scan and the MRI.

The CT scan is the first-line examination in an emergency situation. It makes it possible to distinguish acute inflammatory symptoms of gastrointestinal or urinary etiology from those of gynecological etiology. However, this is a radiation technique, a fact that should not be overlooked, since these are most often women of childbearing age. Thus the MRI should be preferred whenever possible for this diagnostic purpose, particularly in pregnant patients.

The CT signs have been taken from the literature review by Sam et al. [9]. On the CT as on the ultrasound, endometriosis manifests as an enlargement of the endometrial cavity, which may either be enhancing or the site of fluid retention. That feature is totally nonspecific. It also shows tubal dilatation, in the form of serpentine structures that, in 20% of cases, may contain an air-fluid level in a context of pyosalpinx. Ovarian involvement may manifest either as a totally nonspecific appearance of oophoritis resembling a large multicystic ovary enhancing after iodine injection, or an actual adnexal mass with hypodense thick walls which, here to, absent any context, may suggest a suspicious ovarian lesion (Fig. 6), especially as it is most often associated with pelvic edema, which manifests as ligament thickening and infiltration of peritoneal fat. In a context of acute abdominal infection, the pelvic edema caused by inflammatory disease of genital origin may be deceptive, since it can induce thickening of adjacent organ walls and suggest an incorrect diagnosis (appendicitis in particular).

In case of difficulty characterizing an adnexal mass on the ultrasound, the pelvic MRI can be a valuable alternative to the CT scan. Like the CT scan, it should certainly not be used as the first-line examination before an endovaginal ultrasound. The MRI may allow a better analysis of the different structures by showing a tubular adnexal structure with moderate hyperintense signal on T2-weighted images, comprising thickened intensely enhancing walls after gadolinium injection [10]. As with most pelvic inflammatory phenomena, there is infiltration of the perilesional fat, manifesting as moderately poorly delimited hypointense signal on T2-weighted images and often adhesions.

**Chronic stage of PID**

The main problem in this stage is to recognize this with no suggestive clinical context. Most often, it is discovered incidentally during an abdominopelvic ultrasound for another condition. It may also be revealed during an exploration of pelvic pain or infertility. Finally – and this is perhaps the major diagnostic challenge – it can mimic ovarian cancer. Any value of imaging will be to limit the number of exploratory laparoscopies, which are needless and may even...
be deleterious to the patient, which are associated with major anxiety due to findings of lesions characterized as suspicious.

**Distinguishing a tubo-ovarian abscess from ovarian cancer**

On the endovaginal ultrasound, a tubo-ovarian abscess presents in the form of a complex mass, and the tubular character of the fallopian tube has often disappeared. With an indeterminate mass on the ultrasound, the pelvic MRI is the best technique for making diagnostic progress. Specifically, for differentiating between abscess and ovarian cancer, it has been shown that the MRI has better sensitivity, specificity, and accuracy than the ultrasound [4]. On the MRI, the tubo-ovarian abscess presents in the form of a heterogeneous adnexal fluid image with a hyperintense peripheral halo on T1-weighted images, content with hypointense signal on T1-weighted images and moderate hyperintense signal on T2-weighted images (called shading by some authors), and a thickened intensely enhancing wall after injection of contrast agent, synchronously with myometrial activity (Fig. 7) [4,11]. The intensity of the fluid signal depends on the viscosity and protein concentration of the lesion [12]. The presence of gas is also specific to a tubo-ovarian abscess, but it is found in only 22–38% of lesions [11,13]. Along with these direct signs, there are many perilesional signs suggestion infectious disease (Fig. 7): infiltration of perilesional fat in the form of moderate hypointense signal on T2-weighted images, adhesions isointense on T1-weighted images and clear hypointense signal on T2-weighted images, enhancing after gadolinium injection, thickening of uterosacral ligaments, enlarged lymph nodes, etc. [11] When tubo-ovarian infection is suspected, it is essential to explore the other adnexum. The infectious process most often affects both adnexa, possibly to different degrees, if there is a time difference.

**Recognizing pathological sequelae related to a history of PID**

An acute tubo-ovarian episode may progress either toward a cure or toward clinical sequelae (infertility, ectopic pregnancy, chronic residual pelvic pain) and/or radiological sequelae (Fig. 8).

**Hydrosalpinx and tubal obstruction**

PID is the most common cause of tubal obstruction [14]. When there is a tubal obstruction, hysterosalpingography shows a clear stoppage of contrast agent, with no opacification of the distal portion of the fallopian tube. When the obstruction is ampullary, the fallopian tube may dilate and form a hydrosalpinx. Six percent of patients who have had a tubal infection develop hydrosalpinx within 3 months [15].

On the ultrasound, hydrosalpinx manifests as a tubular structure with a very visible, fine echoic wall with incomplete partitions, with a few persistent endoluminal structures (“beads on a string” sign) and anechoic content [16]. Hydrosalpinx may be confused with an epithelial ovarian tumor. The tubal cilia may be confused with papillae (on
Figure 7. Same patient; the pelvic MRI provides additional characterization components compared with the CT scan. In addition to the adhesions, we clearly see enhanced after gadolinium injection, the diffusion imaging shows no hyperintense signal, which is very suggestive of benignity.

a slice perpendicular to the fallopian tube where it creates a "beads on a string" sign) or with participations (on a slice parallel to the fallopian tube where it takes on the appearance of incomplete septa). The distinction is made based on the tubular character of hydrosalpinx, which is shown by rotating the probe and placing it in the long axis, and on the subtle abnormalities: the papillae vary in size and are located on walls that vary in thickness, contrary to the tubal cilia with a "beads on a string" appearance (which are the same size and located on a thin wall). The Doppler is not helpful for characterizing hydrosalpinx. The flow varies in the wall depending on the duration of the condition and its inflammatory nature. It can be helpful if there is a doubt between hydrosalpinx and a dilated venous structure.

Peritoneal inclusion pseudocyst
An inclusion pseudocyst is a quintessential formation found incidentally during an abdominal and/or pelvic ultrasound. The main problem is then to be able to differentiate it
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Figure 8. Follow-up CT scan 2 months after antitubercular therapy. Note the decrease in the adnexal masses and peritoneal effusion.

Figure 9. Endovaginal ultrasound focused on the right adnexa.

from an ovarian cystic formation and to limit the number of needles exploratory laparoscopies for that indication. An inclusion pseudocyst occurs in patients with pelvic adhesions (either of infectious etiology or post surgical) and reflects non-free effusion in the peritoneal cavity [17]. Thus it has no wall per se; its wall consists of adherent adjacent organs. On the MRI, it is recognized by its quadrangular shape, which can be difficult to confirm. The best diagnostic sign is sonographic. Not having any wall, the pseudocyst deforms on abdominal pressure. Its echogenicity varies. There is no correlation between the amount of fluid and the severity of the infection [5].

Special case of pelvic actinomycosis

Actinomycosis is a particular pelvic infection that must be specifically tested for, since it requires special staining to be revealed in genital specimens. It is caused by a saprophytic microorganism belonging to the oral and intestinal flora, *Actinomyces israeli*. It mainly occurs in patients with an intrauterine device. There are few clinical signs and those are most often nonspecific, with a combination of chronic pelvic pain, weight loss, and febricula. In this context, the discovery of peritoneal masses infiltrating the adjacent organs and possibly invading the vessels or compressing the ureters on the imaging studies often leads to an incorrect diagnosis of ovarian cancer. That erroneous diagnosis can be very problematic since first-line surgery in cases of actinomycosis is a source of many complications, which are sometimes serious, while proper treatment with penicillin is most often effective. A preoperative diagnosis is therefore essential. The ultrasound is most often nonspecific. It may show signs of tubo-ovarian infection when there is
abscessing or may sometimes even visualize adhesions. In a context of chronic pelvic pain, the differential diagnosis with deep subperitoneal endometriosis can be complex. On the CT scan, actinomycosis presents in the form of peritoneal masses enhancing heterogeneously in 80% of cases [11]. The CT scan is valuable for guiding any percutaneous biopsies [18]. On the MRI, peritoneal masses can also be seen in intermediate intensity on T2-weighted images, enhancing after injection. These may wrongly suggest a diagnosis of ovarian cancer. Most often there is major fat infiltration associated with a retractile appearance of the adjacent organs, which can rectify the diagnosis [19]. In the absence of abscessing, simple antibiotic therapy with penicillin is sufficient to cure the patient [20].

Conclusion

Thus imaging plays an essential role in aiding the diagnosis at the subacute or chronic stage of pelvic infection. Furthermore, the CT scan in particular can play a therapeutic role for percutaneous draining of in pelvic abscesses, whether of local or remote origin.

**TAKE-HOME MESSAGES**

- Endovaginal ultrasound is the key examination for diagnosing pelvic infection, typically when looking for bilateral adnexal disease with a tubular shape and blunted margins.
- Due to its dynamic nature, the ultrasound allows easier recognition of thickened tubal cilia (whose cross-sectional appearance may be confused with vegetation) or a peritoneal inclusion pseudocyst (depressible on abdominal palpation of the walls).
- After the infectious episode, this diagnosis can be suggested when there is a complex mass with perilesional fat infiltration, that is possibly retractile (actinomycosis), in combination with tubal dilatation.
- The signs of pelvic infection are relatively nonspecific: it should be suggested in cases when there is bilateral involvement, tubular adnexal masses, and perilesional infiltration associated with endometrial thickening, regardless of the imaging technique used (ultrasound, CT scan, or MRI).

**Clinical case**

This patient was referred 3 days after hysterography for right pelvic pain (Fig. 9).

**Questions**

1. What are your diagnostic hypotheses?
   A. Tubo-ovarian abscess
   B. Salpingitis
   C. Pyosalpinx
   D. Tubal torsion
   E. EP

2. What diagnostic studies do you request?
   A. CT scan
   B. Pelvic MRI
   C. PET scan
   D. Diagnostic laparoscopy
   E. None

3. What are the subsequent risks to the patient?
   A. EP
   B. Adnexal torsion
   C. Tubal cancer
   D. Hydrosalpinx
   E. Dyspareunia

**Answers**

1. C.
2. E.
3. A, D.

**References**

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