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REVIEW ARTICLE

Sonography of the Pelvic Infection

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ABSTRACT

The sonographic diagnosis of pelvic inflammatory disease (PID) is a challenge for the sonographer. Sonographic diagnosis is possible when tube enlarges and liquid accumulates inside the fallopian tube, a sign that can be detected with vaginal probes. As the disease progresses, more complex images are found depending on the enlarging of the adnexa and the accumulation of necrotic material. Sonography allows a sensitive diagnostic suspicion in the case of women with clinical and epidemiologic criteria for PID.

Keywords: Drainage, Pelvic infection, Pelvic inflammatory disease, Salpingitis, Sonography, Tubo-ovarian abscess.

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ABSTRACT

It is well known how pelvic inflammatory disease (PID) applied to every inflammation or infection inside the pelvis, which by general rule affects the genital organs and is hereditary. According to the Centers for Disease Control and Prevention (CDC) in the United States, one condition concerning PID would be the absence of the relationship with pregnancy or surgery.[1]

Depending on the affected organs, the disease has received distinct names, which appear in Table 1, but in this day and age, the most utilized term for the disease is PID. With the exception of numerous occasions, it is very difficult to individualize these cases and when the disease is initiated, it will affect progressively some of the organs or others. The biggest protagonists are the fallopian tubes, which are always involved.

The disease begins with an acute case of salpingitis (often silent), although if treated well results without relapses, but in a case that it is not treated or is done so inadequately, the disease could evolve into a more serious form, toward the absence of any localizations (tubal, pyosalpinx, ovaric, tubo-ovarian, pelvic). If the process is stopped and cured in this stage, relapses are always discarded.

From the first visit to the clinic, the most used classification is the Monif (Table 2), which is the one that we will refer to for the sonographic findings.

Laparoscopy has been, until this moment, the most precise diagnostic method to diagnose a case of salpingitis, classifying the findings according to Table 2. However, its utilization is not always available or justified, especially in those cases with acute symptoms. In addition, the laparoscopy does not detect cases of endometritis and cannot detect cases of acute salpingitis.

Table 1: Terminology

Affected Organ	*Name*
Uterus	Endometritis, myometritis
Fallopian tube	Salpingitis, tubal abscess
Ovary	Oophoritis, ovarian abscess
Parametritis	Parametritis, pelvic-cellulitis
Peritoneum	Pelviperitonitis
Vessel	Thrombophlebitis, lymphadenitis

Table 2: Stages of PID

Stage I	Acute salpingitis
Stage II	Acute salpingitis with tubarian abscess
Stage III	Formation of abscess: Tubal (pyosalpinx), ovarian, tubo-ovarian, or pelvic abscess
Stage IV	Rupture of the abscess

STAGE I: ACUTE PHASE – SALPINGITIS

Normal uterine fallopian tubes are not visible in standard condition (the normal diameter of a fallopian tube should not exceed 4 mm).[2] It is assumed that the fallopian tubes are normal in the absence of adnexal out-of-ovary images, but not being able to visualize the fallopian tube does not mean that you can assume its permeability.

A normal fallopian tube can be seen by means of a transvaginal sonogram, if free liquid exists in the bottom of the Douglas pouch (Fig. 1). Further, a portion of the ampulla can be seen, including the fimbrias (Figs 2 and 3). If the liquid surrounds the fimbria, more extension of the tube can be seen (Fig. 4), but it is difficult to see all of its length.

The diagnosis of initial acute PID (acute salpingitis) begins with a challenge for the doctor, due to the little sensibility of the clinic's criteria. According to L Jacobson and L Westrom,[14] the probability of fulfilling all of the

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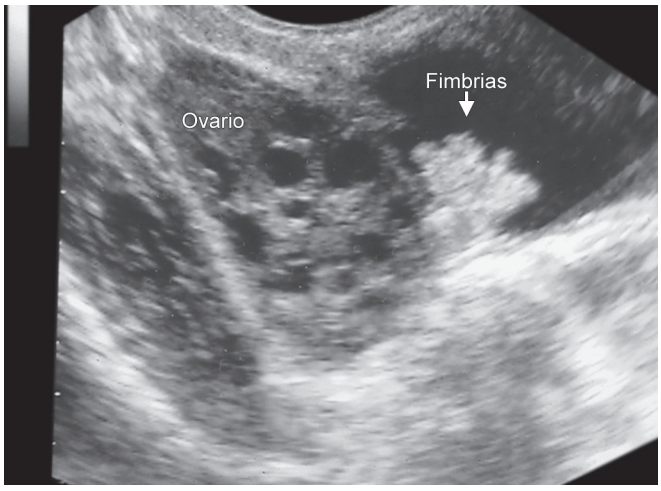

Fig. 1: The free intra-abdominal fluid allows seeing the fallopian tube

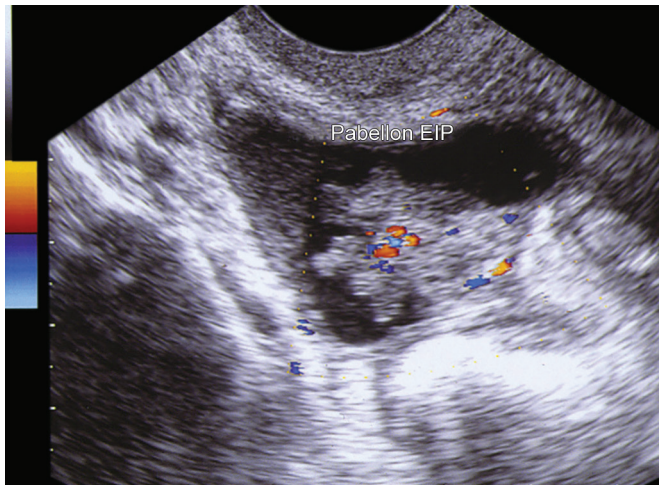

Fig. 2: Fallopian tube with free fluid in the pelvic cavity

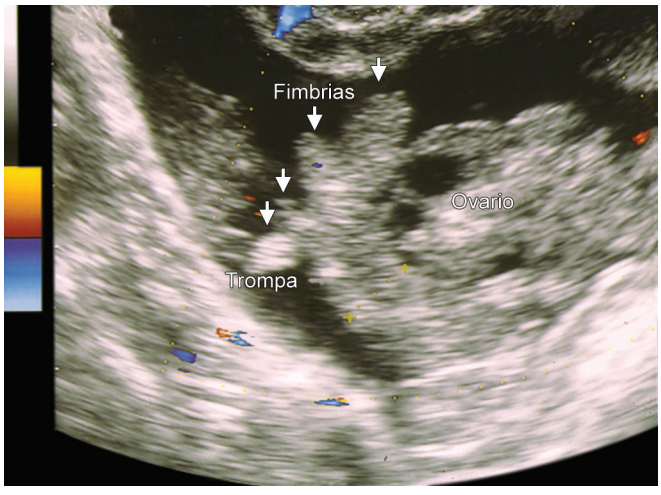

Fig. 3: Tubal fimbriae. The surrounding free fluid allows the visualization of the fallopian tube

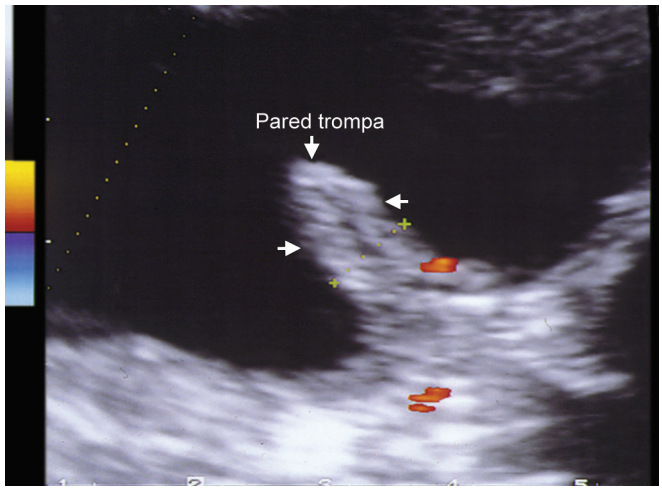

Fig. 4: Tubal tract

major criteria is at 16.1%, the probability of fulfilling all of the major criteria and one minor is at 28.3%, and the probability of fulfilling all of the major criteria and two minor is at 38.7%.

It is difficult to diagnose a disease that includes an acute state and, especially, with these minimum findings that can cause relapses like infertility and complications like an ectopic pregnancy.

For this reason, the necessity arises to identify those signs in the ultrasonograms that create suspicion of salpingitis and that could direct us toward a more precise diagnosis, mainly in those cases of atypical pain and in those cases where the absence of treatment could provoke chronic pain or cases of sterility that had been possible to avoid in the diagnosis and treatment processes. The CDC recommends the empirical treatment of those women who suspect PID and present the major diagnostic criteria, but this procedure allows us to use treatment processes that do not correspond with PID, with the morbidity that supposes an inadequate treatment.

The sonographic diagnosis of salpingitis is a threat for a sonographer. Acute salpingitis can begin with a diagnosis the moment in which the liquid is accumulated in the interior of the fallopian tube (Fig. 5) and is dilated (Fig. 6), signs that we can now detect with vaginal probe. Salpingitis might be seen as a thick echogenic wall and increased blood flow on Doppler imaging.[3] At this moment, the restoration of suitable treatment can allow the case to be cured or regress, with or without relapses, and already this inevitably is always unexpected.

STAGE II: SALPINGITIS WITH ABSCESS

Two events mark the passage into this stage: the obvious engrossment of the fallopian tube and the free liquid inside the cavity. The fallopian tube is inflamed by the accumulation of the liquid in the interior, transudate in the tubal light (Fig. 7), or by the pronounced engrossment of all of the anatomy (Figs 8 and 9). In both cases, there is liquid in the peritoneal cavity. It is the image observed by the sonograph as sonolucence and the clinic translates it as Blumberg positive.

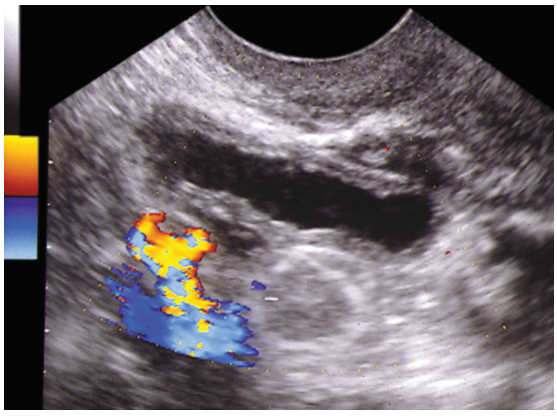

Fig. 5: Initial acute salpingitis. The fallopian tube can be seen when, due to inflammation, fluid fills the tubal lumen

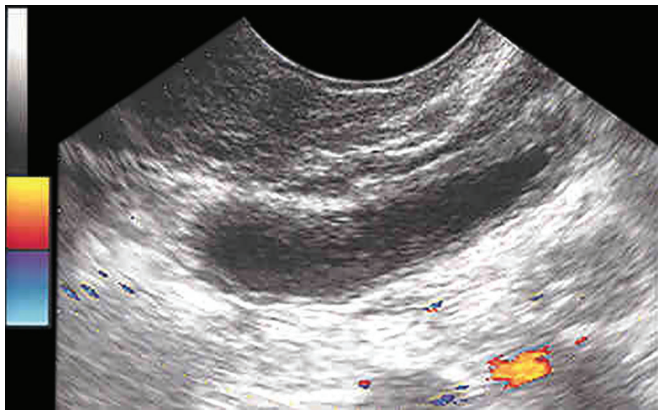

Fig. 6: Acute salpingitis. The fallopian tube is dilated with fluid inside

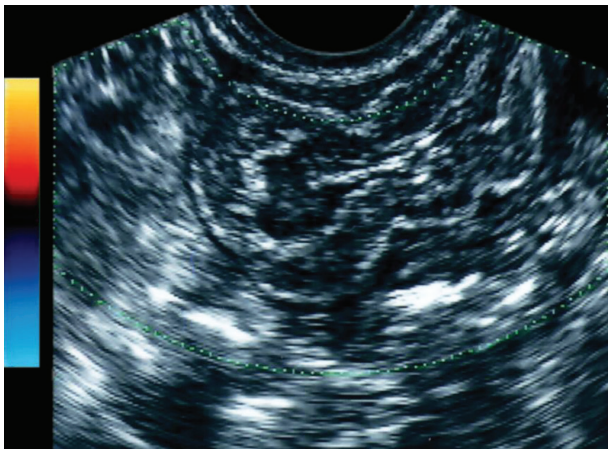

Fig. 7: Salpingitis with pelviperitonitis. Stage II. Fluid filling and surrounding the tube

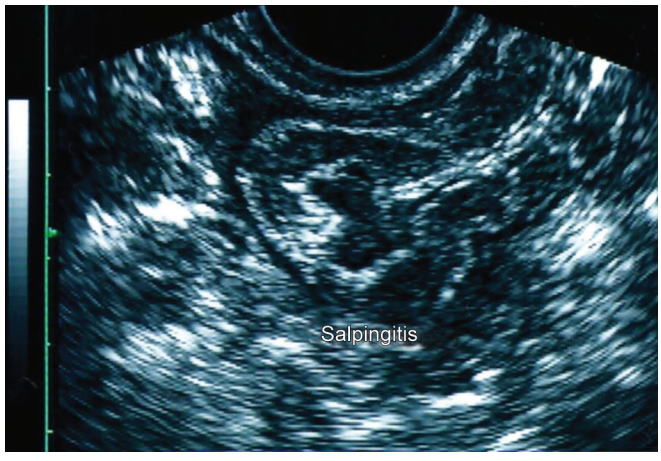

Fig. 8: Salpingitis with pelviperitonitis. Stage II. Thickened fallopian tube with liquid in the pelvis

STAGE III: TUBAL, OVARIC, TUBO-OVARIAN, OR PELVIC ABSCESS

The accumulation of pus inside the fallopian tube gives a location for the tubaric abscess or pyosalpinx, whose characteristic signal is the presence of purulent material in considerable quantities and is obviously visible by means of a sonograph inside the tubal light. But, in addition, there exists a series of characteristic signs that advise us:

- *Beads-on-a-string*: The fallopian tube appears to be dilated, with excretions that project toward the interior of the light, of the same size and distribution. They are the expressions of the destruction of the tubal mucus, whose folds leave a mold and they are perfectly visible by means of the vaginal sonograph (Figs 10 and 11).

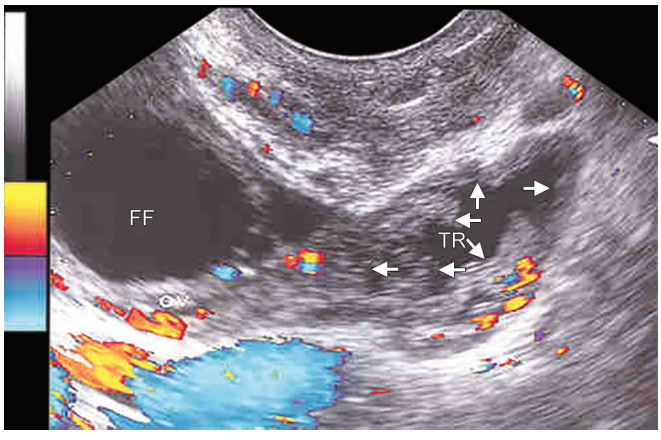

Fig. 9: Salpingitis with pelviperitonitis. Stage II. Thickened fallopian tube. Peritoneal irritation caused by the free fluid in the pelvis that surrounds the fallopian tube and is well outlined

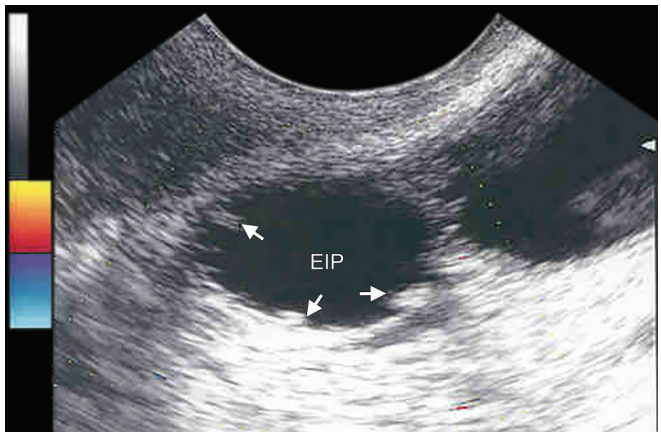

Fig. 10: Sonographic sign of "pearl necklace," evidence of a thin wall with few excrescences of mucus in the interior

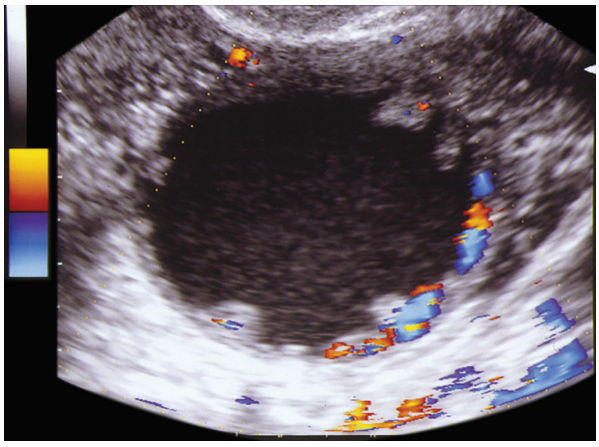

Fig. 11: Sonographic sign of "pearl necklace" view of the fallopian tube where the mucosal excrescences appear

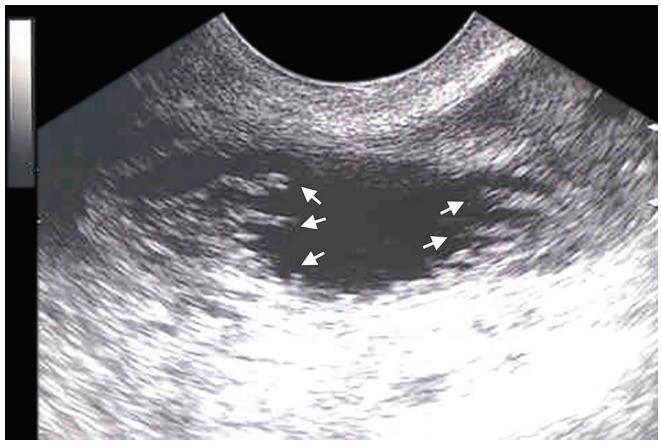

Fig. 12: Pyosalpinx. Sign of the "cogwheel." The excrescences are distributed in irregular forms. Also, it has an image of a pseudo-thin wall

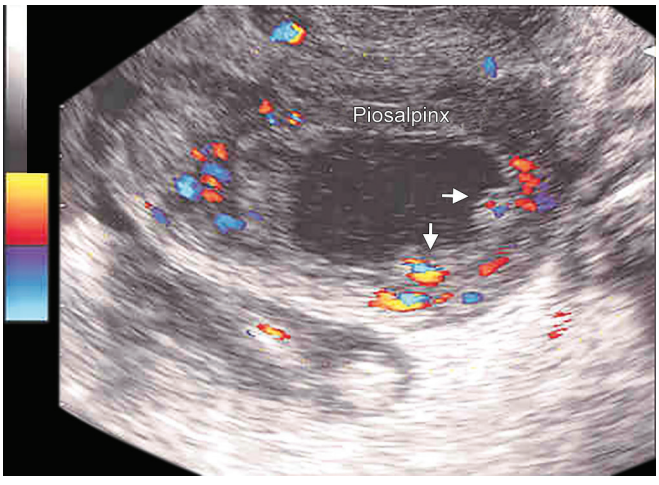

Fig. 13: Pyosalpinx. Sign of "cogwheel." Sonographic contents of pus

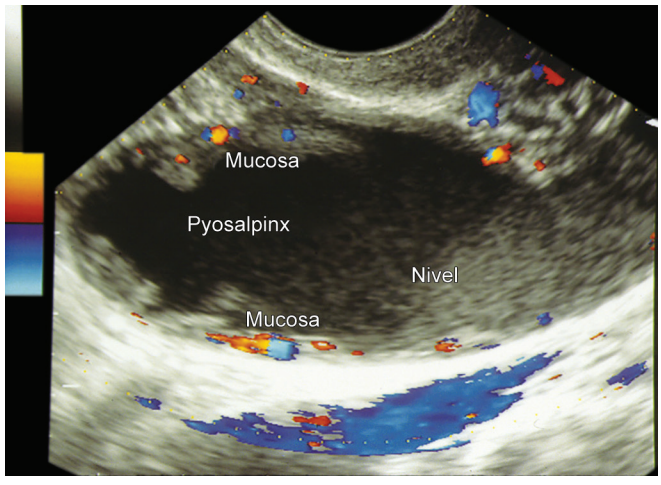

Fig. 14: Pyosalpinx. Sign of "cogwheel." Irregular excrescences inside the tubal lumen

- *Cogwheel*: The fallopian tube appears dilated with irregular excrescences, and already disorganized, that are projected toward the interior light.[3] They are signs of important destruction inside the fallopian tube with large contents of pus (Figs 12 to 14). The cogwheel sign is also a specific sign of PID (95–99% specificity), but it seems to be less sensitive (0–86% sensitivity).[4]
- *Incomplete septa*: It is an image of the pseudo-thin wall that does not arrive to occlude the complete tubal light. When the affected are seen in the inflammatory process, the fimbrias can provoke the fallopian tube to close. The exudate that is accumulated in the light can reach dilation of the fallopian tube in such a method that this folds over the same (Figs 15 to 17).
- *Wall thickness*: It is important to distinguish if the thickness of the tubal wall is larger or smaller than 5 mm. The result of the thick wall follows the acute process, in those processes that are frequently present in the tubular edema (Figs 18 and 19). On the contrary, the finding of a thin wall can suggest tubal fibrosis. Thick tubal walls is a specific and sensitive ultrasound sign of acute PID, provided that the walls of the tubes can be evaluated, i.e., when fluid is present in the tubal lumen (100% sensitivity).[4]

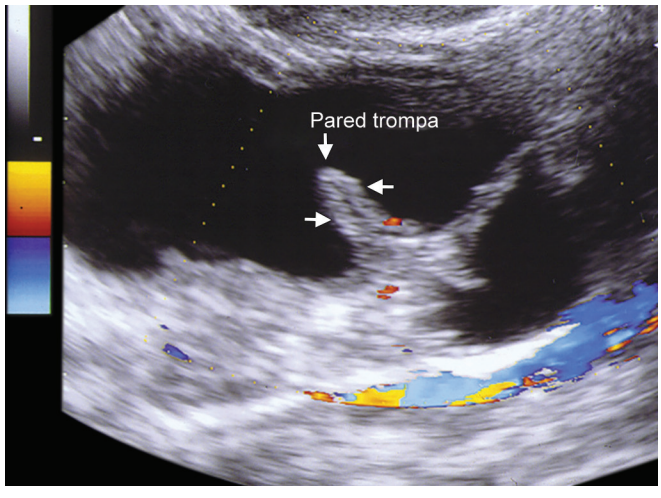

Fig. 15: Pyosalpinx. Septa inside the fallopian tube, fold in the fallopian tube

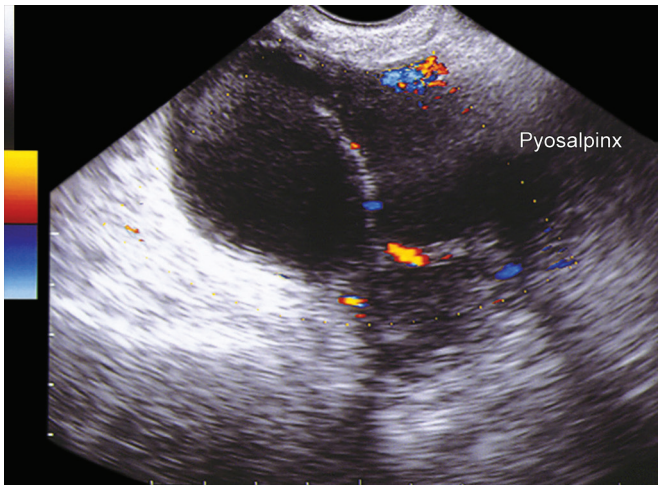

Fig. 16: Pyosalpinx. Incomplete septa. When the fallopian tube is dilated and folded, a sonographic sign of incomplete septa is seen. Echorefringent material inside the fallopian tube

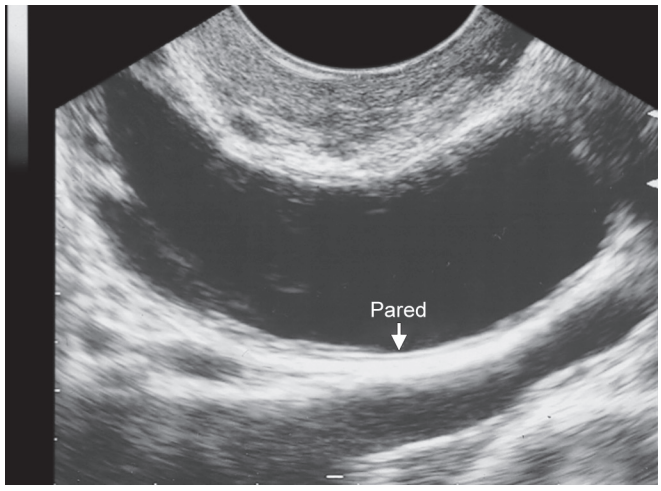

Fig. 17: Pyosalpinx. Incomplete septa. A sonographic sign of incomplete septa is important to identify the tubal origin of the complex anexial mass. Observe the destruction of the tubal wall

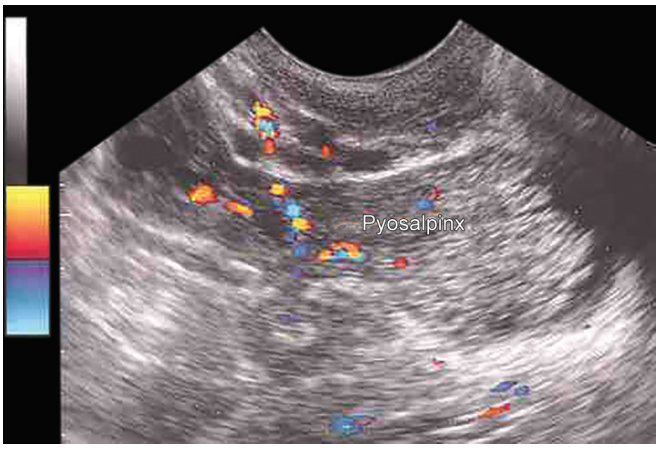

Fig. 18: Pyosalpinx. Thickening of the tubal wall that is characteristic of the acute process. Refringent material in its interior that indicates pus. The color map shows intense inflammation

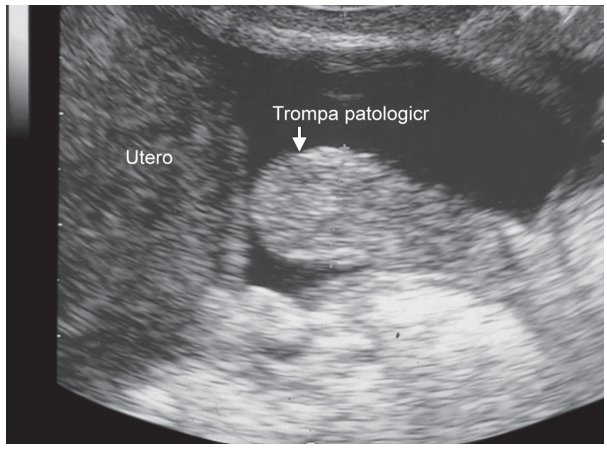

Fig. 19: Pyosalpinx. Thickening of the tubal wall ending in the cul-de-sac through distal stenosis of the fallopian tube

- *Tubal contents*: Its content has variable signals: totally anechoic, complex, suggesting pyosalpinx, and due to the purulent material (Fig. 20) or show an air-fluid level, which is pathognomonic.[5]
- *Tubo-ovarian complex*: It is possible to recognize the fallopian tube and the ovary, but it is not possible to separate when we intend to differentiate the two with a vaginal probe. This could be due to the fibrous deposits that are formed during the inflammatory process, which surround the fallopian tubes and attach to the ovary (Figs 21 and 22). In the tubo-ovarian complex, the ovary is often affected (oophoritis), which could be seen as an ovary increased in size and with loss of the corticomedular differentiation.[5] There has been found an increased volume in the ovaries with decreasing volume in their follow-up evolution.[6]
- *Tubo-ovarian abscess*: This is the next step wherein the ovarian involvement is such that these two structures merge and can no longer be identified by sonography.[5]

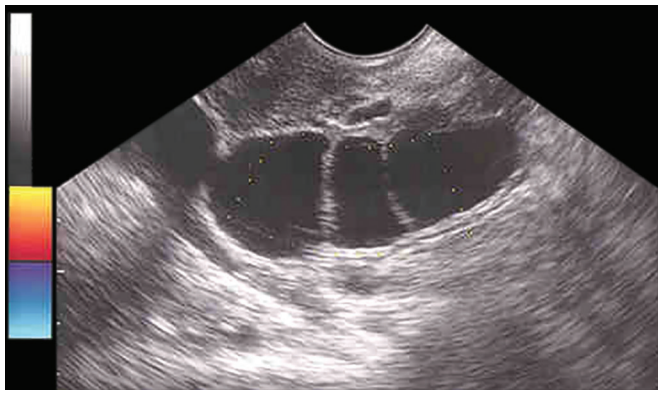

Fig. 20: Pyosalpinx. All signs. Refringent contents, pseudo-thin wall, excrescences. Thickening of the tubal wall

Bilateral adnexal masses appearing either as small solid masses or as cystic masses with thick walls and possibly manifesting the cogwheel sign also seems to be a reasonably reliable sign (82% sensitivity, 83% specificity).[4]

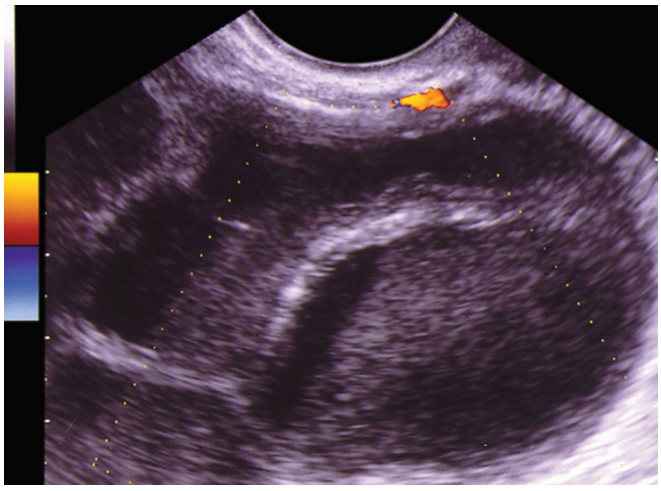

Fig. 21: Tubo-ovarian abscess. Complex attachment in which the fallopian tubes surround the ovary

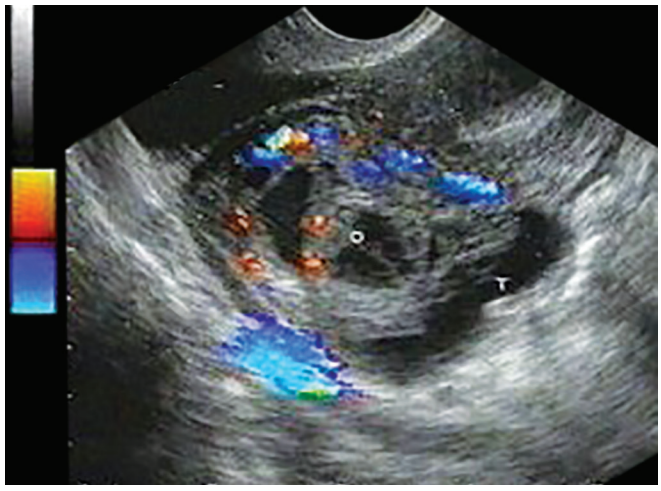

Fig. 22: Tubo-ovarian abscess. Tubo-ovarian complex in which is it difficult to distinguish the limits of the ovary or the dilated fallopian tube

Table 3: Laparoscopic classification of PID

Acute	Erythema and edema of the fallopian tube
Moderate	Fallopian tubes with purulent excess
Severe	Pyosalpinx, tubo-ovarian abscess, tumor, inflammation

According to our experience, the sign of incomplete septum and tubal contents of mixed echorefringence are the most characteristic findings of pyosalpinx and tubo-ovarian abscess. In Table 3, we show the frequency of those signs in our series, including the rare cases that we had on occasion to contrast the diagnosis for laparoscopy or laparotomy.

We believe that acute salpingitis generally runs without trouble or difficulty to the sonographic signs although it manifests pain in the adnexal exploration of the vaginal probe. If salpingitis is really acute, the fallopian tube dilates, providing evidence of edematized, and a thin wall is confirmed (a sign of "cogwheel"), and it fulfills the generally mixed contents. If it evolves to tubo-ovarian abscess, the fallopian tubes are seen as very dilated and elongated to the ovary, that which is badly defined, with the signs of incomplete septa, mixed contents with levels and free liquids in the Douglas pouch. If both tubes are affected, the complex typically takes on a "U" shape and it fills all the cul-de-sac extension.[6]

The color Doppler also contributes to the diagnosis that defines the inflammation that is characteristic of the acute process, but more irritation exists. Therefore, it detects more color signals in which the process already freezes (Figs 23 and 24).

The fact that no control group is used, due to the characteristics of the disease and the impossibility to visualize the normal fallopian tubes sonographically, prevent us from obtaining the sensibility and actual specificity of the sonograph.

Ultrasonography is very illustrative in the serious cases, and in the cases that are very acute, we put aside the processes with similar symptoms. The ability to explore with a vaginal probe attached permits us to perform a directed exploration, reaffirming the origin of the directed pain. Even though, sometimes the transabdominal approach can be useful when subtle

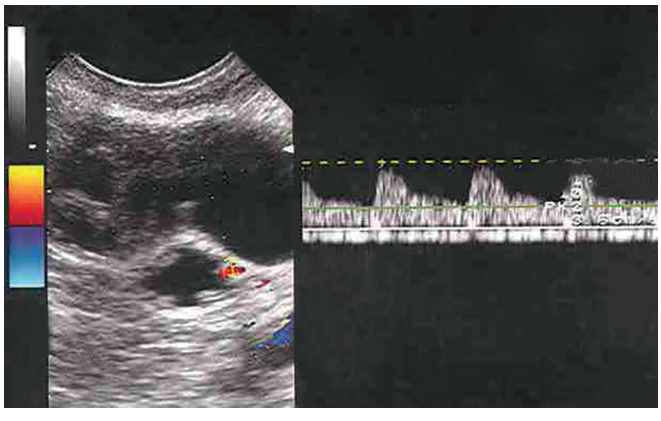

Fig. 23: Sign of color Doppler throughout the tube suggesting acute infection

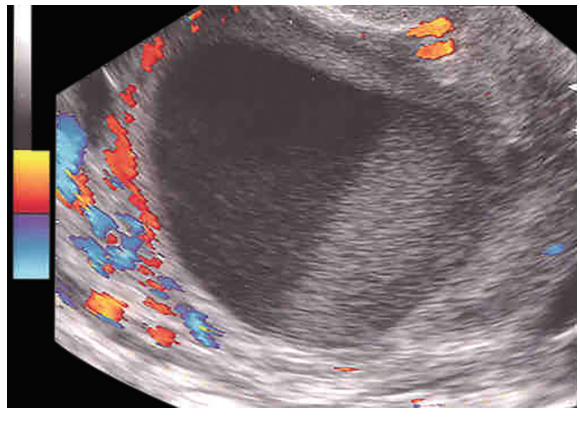

Fig. 24: Exuberant color map in the tubal wall, with a very dilated fallopian tube. Suggestive of acute infection

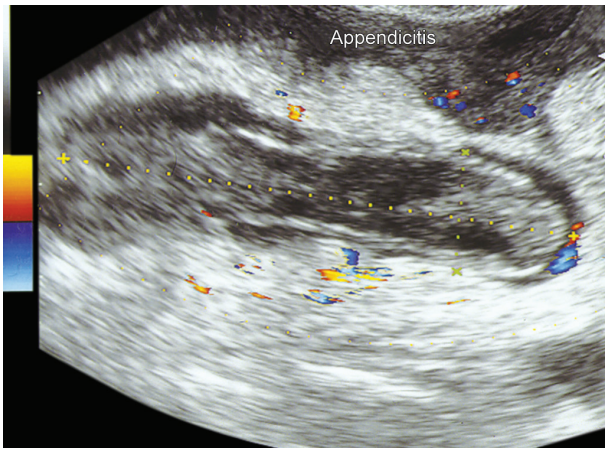

Fig. 25: Acute appendicitis. Inflamed and thickened appendix, with positive Doppler sign

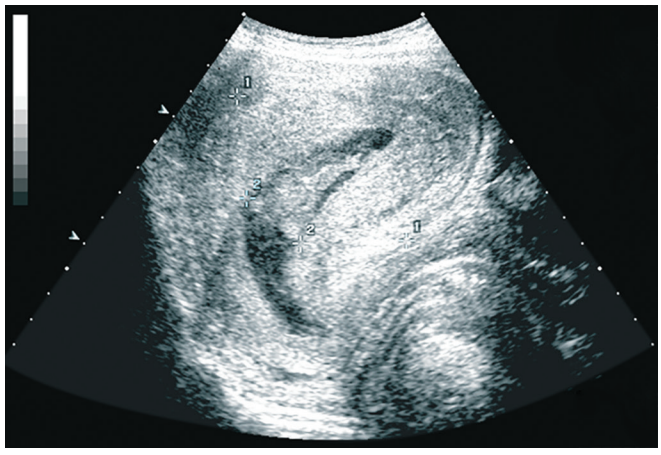

Fig. 26: Endometritis

changes in uterine size or in the adjacent fat are looked for.[6] Additionally, it is important to recognize that acute appendicitis (Fig. 25) can have some symptoms and sonographic signs similar to those of acute salpingitis. Also, ovarian torsion can be similar to an inflammatory mass and that is a surgical urgency; Doppler can help us in this case to diagnose it.[3]

Doppler Findings in PID

As we know, PID causes tissue inflammation; as a result there is vasodilatation, angiogenesis, and an increased blood flow.[7] This physiological response to inflammation could be demonstrated as decreased pulsatility index (PI) and resistance index (RI) values of the uterine arteries.

There are studies that correlate improvement of infectious parameters (such as white blood cell count and C-reactive protein) with an increase in the Doppler values of uterine arteries (PI and RI) measured at day 1 and 7.[8]

ENDOMETRITIS

It has been confirmed that PID is an infection inside the pelvis that affects the feminine genital organs. It should be added that this occurs, generally, outside of the uterus. This is because the periodic menstrual desquamation most likely protects this organ. Obviously, this is not always the case, and sometimes the uterus can be seen wrapped up in the process, producing endometritis and less frequently, myometritis. Since this point can be seen from the sonographic view, the infection of the uterus can be manifested in two forms:

1. The presence of refringent spotting that passes through all of the endometrial line (Fig. 26).
2. The accumulation of liquid, translated in the sonolucence inside of the uterus cavity (Fig. 27) that can produce the dilatation of the endometrial cavity (more than 14 mm).[3] Sometimes there is intrauterine gas.[9]

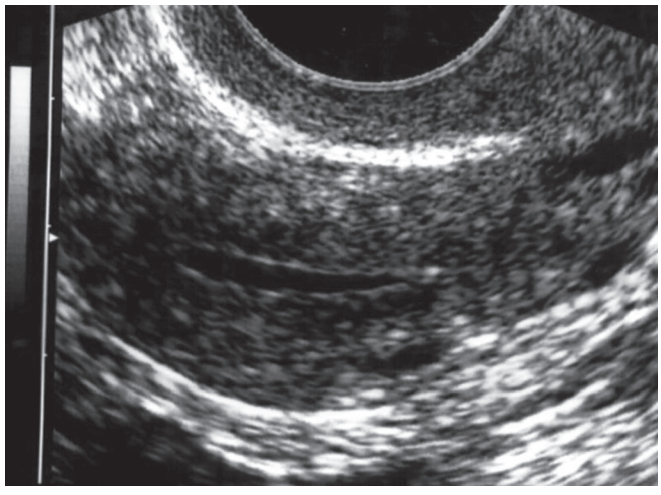

Fig. 27: Accumulation of fluid in the cavity. Endometritis

HYDROSALPINX

It is the most frequent result of PID. After an acute inflammatory or infectious process in any previous phase described, and with the adequate medical treatment, the process can be cured with the elimination of the aerobic germs and anaerobic causes of the disease. If acute salpingitis is treated, it can evolve with restitutio ad integrum, but immediately the disease finds itself a little more advanced, and concerning all the cases in Stage III, this is not possible and we find our collections of liquid with germs inside the fallopian tube. This condition is known as hydrosalpinx. From the point of view of the sonograph, the lengthened tubal structure is identified (Figs 28 and 29), with a fine wall of mucus atrophic (Fig. 30) and containing sonolucent (a typical characteristic) (Fig. 31). The lesions of the tubal mucus will depend on the gravity of the process, but the contained sonolucent creates an acoustic window that permits a visual, even better, of the signs described earlier, like the projected cases on the internal edge of hydrosalpinx (a sign of the

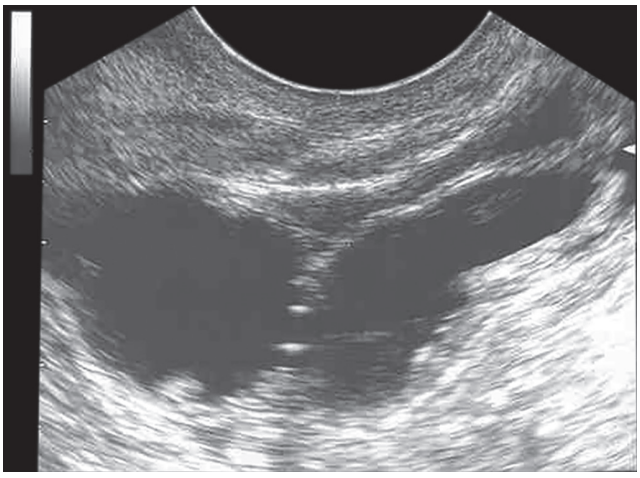

Fig. 28: Hydrosalpinx. Longitudinal view

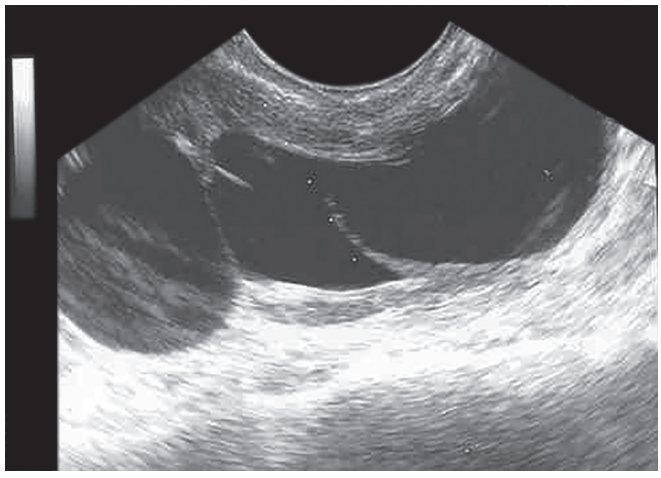

Fig. 29: Hydrosalpinx. Sonoluscent contents

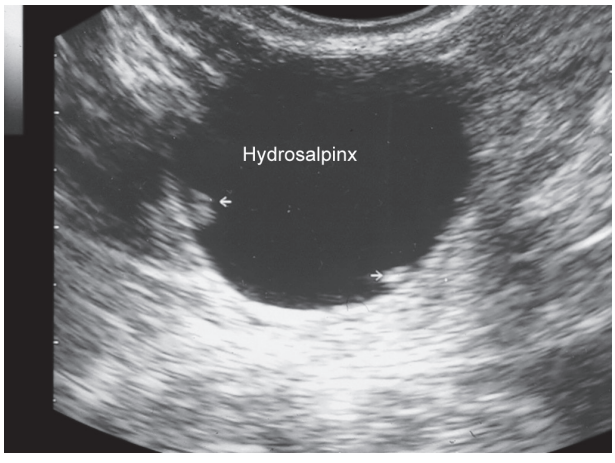

Fig. 30: Hydrosalpinx. Sonoluscent contents. Tubal wall very thinned

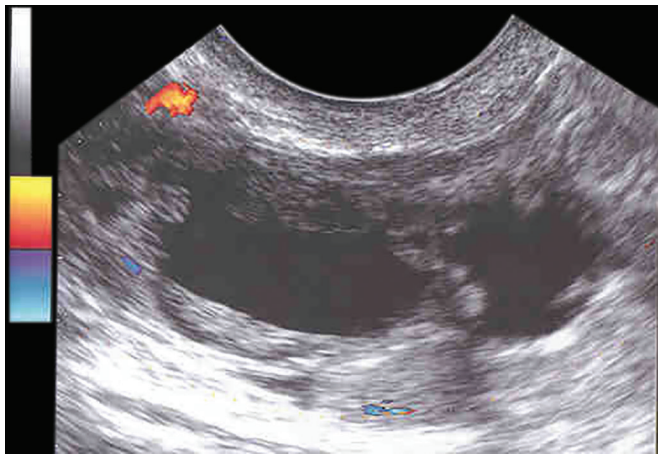

Fig. 31: Hydrosalpinx. Sonoluscent contents. Doppler signs in the wall of the fallopian tube

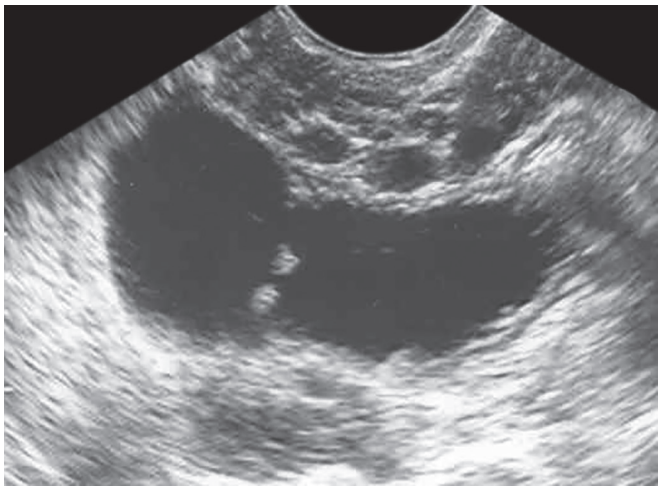

Fig. 32: Hydrosalpinx. It remains a sign of "pearl necklace." There is no activity in the wall. Practically no sign in the Doppler

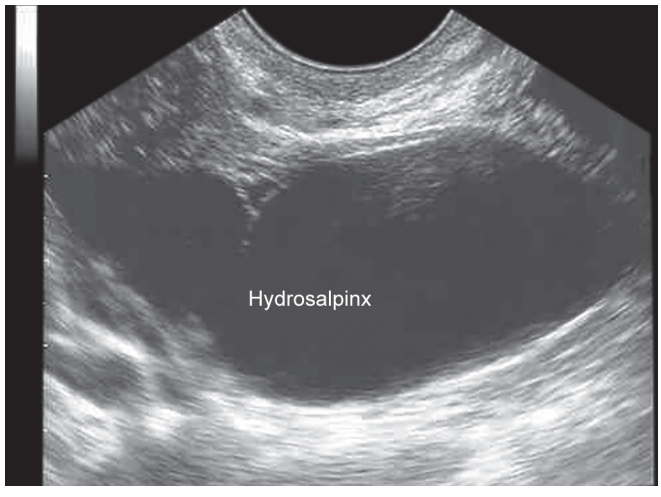

Fig. 33: Hydrosalpinx. Sonoluscent formation. Sign of "pearl necklace." Few Doppler signs

"beads-on-a-string") (Figs 32 and 33) or if the dilated fallopian tube reaches a sufficient size or is double in size (a sign of Incomplete Septa) (Figs 34 and 35). The Doppler is not helpful for characterizing hydrosalpinx.[5]

HYSTEROSALPINGOSONOGRAPHY

The principal proposal of hysterosalpingosonography concerning the tubal pathologies could be the substitution of hysterosalpingography (HSG) in the analysis of

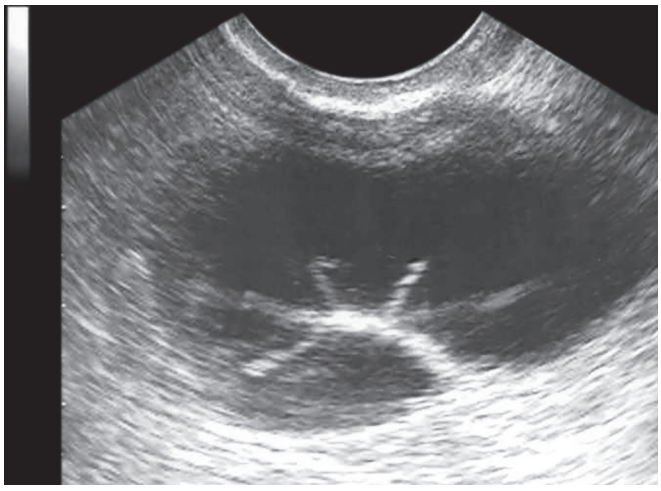

Fig. 34: Hydrosalpinx. Sonoluscent formation. Pseudo-thin wall

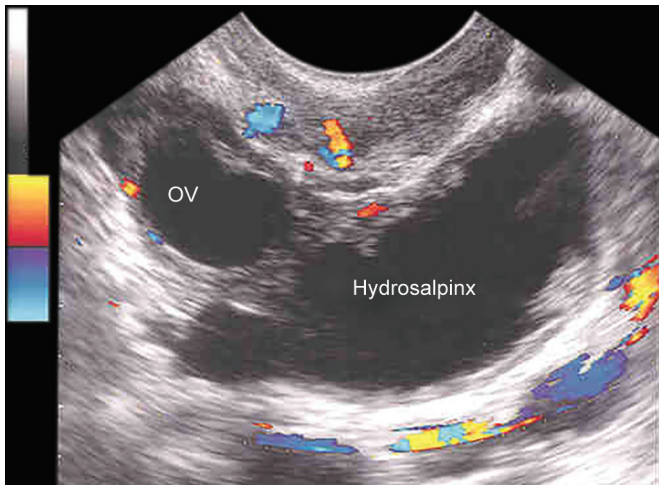

Fig. 35: Hydrosalpinx. Sonoluscent. Detail of the pseudo-thin wall. Tubal mucus destroyed

the fallopian tubes. The published results are interesting and include authors like Goldstein and Yarali who have complemented their work with the use of the Doppler. Nevertheless, the sonographic technology will provide less information about the morphology of the fallopian tube, its internal structure, and the location of obstruction. The analysis of the latest articles about hysterosonography make it obvious that, in reality, the majority of the authors who use this technology in their analysis of intracavity pathology, still appeal to hysterosonography and chromopertubation like the specified technology to demonstrate the tubal permeability. To verify this last claim, it has to be assumed the introduction of a liquid (serum saline or contrast sonograph) through the cervix (hysterosonography). By using this procedure, the passage of opposition or the free liquid in the peritoneal cavity can be visualized, if it is permeable. However, its utilization has not been reached, because it will not provide the information of how its passage occurs and, therefore, HSG cannot be substituted as of now as a method of reference to validate the tubal pathology.[10]

SONOGRAPHIC DRAINAGE AS A GUIDE TO PELVIC ABSCESS PERFORATION

Traditionally, obstetricians and gynecologists, including those before the arrival of sonography, became accustomed to draining the pelvic abscesses that bulge convexly toward the vagina through the Douglas pouch; it became a route with which we were familiarizing ourselves and with the intention to alleviate the pus. Afterward, we have come to project this same idea with sonography on how to give a guide to perforation.[11] In this prospective study published in 1996, in which we randomly selected 40 patients with pelvic abscess to administer medical treatment with antibiotics without further procedure or with medical treatment in addition to abscess perforation by route of the vaginal tract with sonography. We found the latter method shared a much quicker recuperation and reduced the hospital stay, with statistically proven differences. Similarly, in the study group, a smaller number of laparotomies were necessary to provide a motive to use this process.

Our findings were confirmed by a Norwegian study of 302 women, in which the success rate of the procedure was neither affected by the size of the abscess, the presence of bilateral abscesses, nor by the multilocularity of the abscess.[12]

This technique is being used for the drainage of different pelvic abscesses in both men and women. A recent study published an excellent success rate in endoscopic ultrasound (EUS)-guided drainage of pelvic abscesses; they show a series of 30 patients including 4 prostatic abscesses, 7 perisigmoid abscesses, and 19 perirectal abscesses; the interventions included aspiration only (2 prostatic and 3 perisigmoid), aspiration and dilatation (2 patients in each group), and dilatation and stenting (2 perisigmoid and 17 perirectal). Technical success of EUS-guided pelvic abscess drainage overall was 90.9% (30/33), and was 93.3% (27/30) in patients in whom EUS-guided drainage was attempted.[13]

Recently, this pathology, whose incidences have diminished, begins anew as they are found in the clinics' perhaps the product of promiscuity and with attention to the emigrant populations, for who we believe that they have the technology that could result beneficially that is simple to perform and possess inherently few complications.

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