Chapter 14

Differential Diagnosis for Female Pelvic Masses

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Additional information is available at the end of the chapter

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1. Introduction

The female pelvis is an anatomic region which is quite complex, because it contains some organs and systems accomplishing different and independent functions. The uro-genital system represents the main part of the female pelvis but there are also portions of other organs and systems such as some important blood vessels, gastrointestinal tracts, lymphatics, nerves and parts of the musculoskeletal system. All these structures might house or generate pelvic masses even in para-physiologic conditions, and not necessarily because of current diseases, or congenital alterations, inflammatory illness and tumours.

In order to understand the nature of a pelvic and/or abdominal mass it is necessary to collect as many as possible clinical data. A clinical classification constitutes the first step for finding out the aetiology. The age is indicative for diseases linked to different functional periods of the reproductive system; clinical history must investigate upon possible previous tumours, infectious or metabolic diseases and surgery. When collecting clinical history, pelvic pain which can be divided into acute, chronic and cyclic, must be directly addressed; alterations of body temperature, gastrointestinal symptoms (nausea, vomiting, diarrhoea, constipation, hematemesis, melena), urinary tract symptoms (oliguria, polyuria, stranguria, hematuria, urinary retention, incontinence), taste disturbance; pharmacological treatment in progress (anticoagulants), previous radiotherapy must be addressed.

The are several gynaecological causes responsible for pelvic tumours. These are reported in table 1.

SITE	DISEASE
Ovary:	endometriosis
	organic and functional cysts
	benign and malignant cancers
	metastasis
Fallopian tube:	tubo-ovarian abscesses, pelvic inflammatory disease
	hydrosalpinx
	para-ovarian cysts
	ectopic pregnancy
	neoplasm
Uterus:	uterus body neoplasm
	fibroma
	malformations
	blood-pyometra

Table 1. Gynaecological abdominal-pelvic masses with malignant clinical features.

It has also to be taken into account the possibility that a non gynaecological lesion could be responsible for a mass. In table 2 the principal non-gynaecological causes for pelvic and abdominal swellings are reported.

The role of medical imaging

The best examination in a clinical context is undoubtedly suprapubic and endovaginal ultrasonography. In young patients, especially in those who are in the reproductive age, ultrasonography shows the best accuracy in the differential diagnosis of ovarian and hydrosalpinx cysts, of the ectopic pregnancy, of uterine fibroids [1].

Ultrasonography permits to distinguish correctly between a benign and a malignant adnexal mass and, within these groups of diseases, to give an accurate diagnosis in most of the cases.

Nevertheless ultrasonography isn't free from errors and limitations. Diagnostic errors are probable in the identification of masses which appear solid at US. In these cases is difficult to evaluate the uterine or ovarian or the extra-gynaecologic origin of the lesion. These cases require CT or MRI scan. In particular MRI has proven to be useful in detecting and staging of gynaecological malignancies and in detecting the origin of extra-gynecological pelvic masses [2].

SITE	DISEASE
Gastro-intestinal tract	appendicular abscess
	neoplasms
	diverticulitis, peridiverticular abscess
	Crohn's disease, segmental ileitis
	impaction
	mesenteric cysts
Urinary tract	pelvic kidney
	bladder globe
	urachus cyst
	bladder tumours
Miscellany	lymphadenopathy
	peritoneal carcinomatosis
	musculo-skeletal tumours
	organ ectopia (migrant spleen)
	pelvic vessel aneurysms
	foreign bodies
	pelvic dysmorphisms
	complications of previous surgery
	hematomas
	musculo-skeletal inflammations

Table 2. Abdominal-pelvic extra gynaecological masses with malignant clinical features

2. Intra peritoneal extra gynaecological masses

2.1. Digestive system

They are intra peritoneal masses which originate from the gastrointestinal system, are localized in the pelvis and concern essentially tumours and inflammatory diseases. It is to be taken into account that, especially in adolescents and old patients who have a very long sigma, the loop can be palpated in the pouch of Douglas simulating, when full of faeces, an ovarian neoplasm.

In adolescents this condition can be caused by colon-sigma non-ganglionic diseases (megacolon), where the altered peristalsis implies an abnormal accumulation of faecal material. This condition can also imply the invagination of intestinal traits which is not so infrequent especially in old patients. Among the digestive system diseases, which very frequently can

simulate a gynaecological neoplasm, we count inflammatory diseases (acute and chronic) and tumours.

2.2. Inflammatory diseases

An acute, but mainly chronic, inflammation could cause the clinical evidence of an abdominal-pelvic mass and the reasons are the following:

- formation of adhesions in intestinal loops, causing wall thickening and rigidity, sub mucosa and mesentery bleeding and oedema, inflammatory reaction of peritoneum and adjacent omentum.
- bowel perforation and formation of peri-visceral phlegmon; in some cases the wall breaking causes the bleeding of an important vessel and shows the symptoms of haemorrhagic or peritonitic acute abdomen.

These anatomic-pathological aspects correspond to different CT scan findings, classified by Hinchey and his team in 4 stages, depending on the inflammation extension [3]:

- Stage 0: inflammatory thickening of the intestinal wall, with oedema of the mucosa, luminal-stenosis, the inflammation being still circumscribed within the bowel wall.
- Stage I-II-III: abscesses, unique or multiple, showing sometimes air-fluid level images connectible to liquid necrosis; generally these abscesses are adherent to the intestinal wall, or to the peritoneal folds. Such a picture corresponds to the condition of the diffusion of the inflammation beyond the visceral wall.
- Stage IV involves intestinal perforation and faecal invasion of the peritoneum (Figure 1).

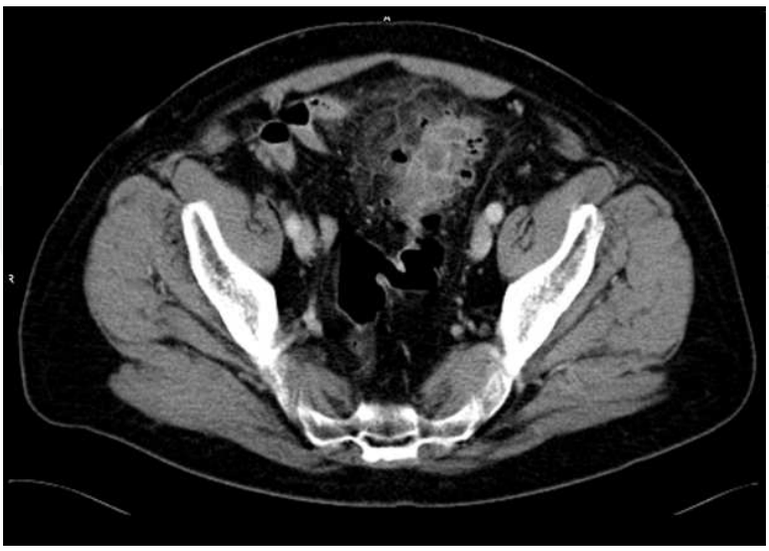

Figure 1. Contrast enhanced CT scan, during a portal phase showing an inflamed sigma, with perforated diverticulum in the medial side of the sigma.

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The intestinal inflammation (whether circumscribed or widespread) might cause fistulas with adjacent anatomical regions and/or the most declivous portions of the pelvis such as the vagina and the rectum. The fistula is often the first symptom of the intestinal wall inflammation.

Besides, in patients with generalized sepsis, CT scan is useful for correctly positioning of drainage pipes into the abscesses in order to clean them up by saline and antibiotic washes [4].

2.3. Neoplasms

Sigma-rectum tumours determine swellings of the left adnexal site, but they may also occupy the whole pelvis or the central portion of it. These tumours might appear as solid masses stenosing the intestinal trait where they originate from, or, rarely, masses with mainly extra luminal development.

Not infrequently, the tumoural mass associate with an intestinal inflammatory disease. Nonetheless, the mesenteric vessel congestion and the presence of small perivisceral liquid collections, appear to be the CT scan signs which are most related to diverticulitis and, to a lesser degree, tumours.

When the neoplasm does not involve the pelvic organs the CT scan diagnosis is simple and easy, showing the reproductive system integrity. Thought not infrequently, an intestinal primitive neoplasm may strictly stick to, and infiltrate the uterus; there might also be observed adnexal neoplastic masses which are not in direct continuity with original neoplasm (Figure 2).

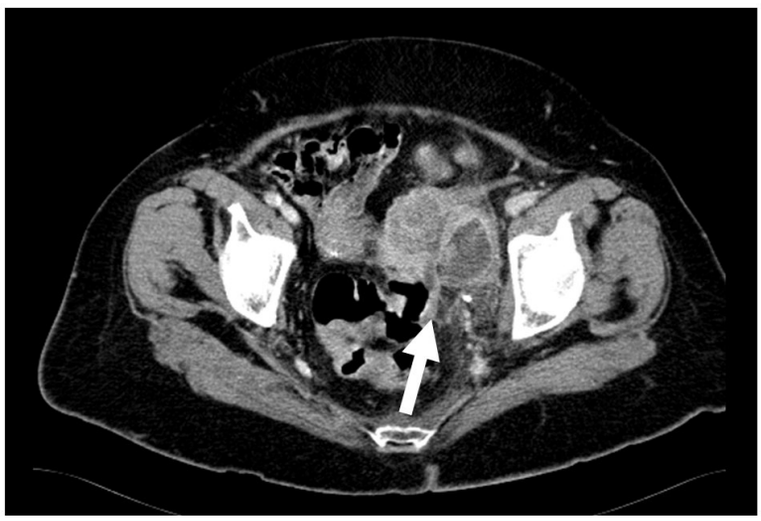

Figure 2. Preoperative axial contrast enhanced CT scan during late phase showing a mass growing in the left ovary (white arrow). An adjacent mass is seen in in the sigmoid colon.

In these cases CT scan is unable to discriminate between a primitive ovarian neoplasm with peritoneal metastasis infiltrating the sigma-rectum, and a primitive intestinal tumour with adnexal metastasis (Krukenberg disease).

2.4. Intra peritoneal foreign bodies

The presence of foreign bodies into the peritoneal cavity represents a not so infrequent finding; they are a consequence of surgical malpractice and that's why they're also known as "gossypiboma". A "textiloma" is a complex made of a non- biodegradable foreign body plus the surrounding reactive tissue [5].

The pelvis can be site of textiloma either because of pelvic or abdominal surgery. In fact the position of the textiloma is affected by the omentum causing the foreign body phagocytosis with consequent fibrinoid-granulomatous reaction and strong adhesions. In this case the textiloma remains into the abdomen. If the surgery implies the removal of the omentum then the textiloma can move to the pelvis. In the case of pelvic surgery, the gossybipoma seems to have greater possibilities of changing its original position and moving either to the pelvic or the abdominal peritoneal cavity.

Recently, in operating rooms, sterile gauze with a radio-opaque marker is being used.

Ultrasonography might be useful in the differential diagnosis of garzomas; they appear as cystic masses, containing the foreign body in their core, with a rather irregular morphology and completely reflecting ultrasonic waves.

At CT scan the finding of a solid mass containing helical, or vortex-like opacities, or the presence of differently dense micro nodules, sometimes calcified, are very suggestive of textiloma. The solid part might be expression of the exudative reaction, while the fibrinoid reaction has a less specific meaning. After c.m. administration a slight peripheral enhancement of the pseudo-capsula. In this case the differential diagnosis with abscesses is very difficult.

At MRI they appear as a solid mass hypointense on T1 and hyperintense on T2, with no specific morphologic features [6].

2.5. Ascites

Very rarely some intraperitoneal liquid collections might be considered as reproductive-system originating tumours. This may happen under particular conditions: patients who underwent previous surgery for abdominal masses; in the cases of intraperitoneal treatment with radioactive drugs where are present so strong adherences causing intraperitoneal fluid flow alterations. Bags of peritoneal effusion may also appear, and they are correctly identified by ultrasonography as liquid masses that can be exchanged as intraperitoneal masses. CT scan results better in defining the liquid bag topography which has low density values (0-10 HU), excluding, more safely, the possibility for the mass to be an intraperitoneal cyst.

2.6. Peritoneal pseudomixoma

It is the accumulation of mucinous material into the peritoneal cavity. It is due to peritoneal metastatic lesions secreting mucin; in most of the cases the principal cause is a mucinous ovarian neoplasia, but less frequently pseudomixomas can be due to malignant mucocele of the appendix and tumours of the stomach, of the colon, of the pancreas and of the breast.

The pseudomixoma typical CT scan appearance is a hypodense, liquid mass localized among the intestinal loops; sometimes, inside the lesions, can be observed images of septa or solid buttons. The HU values range between 15 and 30.

2.7. Mesenteric panniculitis

It's a primitive disease of the mesentery, with intraperitoneal and pelvic metastasis. It is defined as macrophage inflammatory infiltration of the mesenteric fat associated with scar-fibrous component. When this last element prevails, it is defined as liposclerosis. Panniculitis might be also consequent to previous abdominal surgery or radiotherapy.

CT scan is decisive for diagnosis: a fatty mass incorporating some mesenteric vessels without infiltrate them; the mass is homogeneous, circumscribed by a peripheral pseudocapsule well delimited. MRI fat suppression sequences further discriminates the fat components from the liquid ones. These aspects can be unique, affecting portions of the abdominal-pelvic peritoneum with multiple foci.

2.8. Intraperitoneal tumours

Tumours of omentum and intraperitoneal spaces originate from the tissues which constitute these structures: coelomic epithelium, mesothelium, fiber, fat and muscle connective tissue, lymphatic and blood vessels, nerves, embryonic residues. Usually, lesions in these sites are due to primitive abdominal tumours, especially intestinal and ovarian. Therefore, given an intraperitoneal neoplastic mass, it has first to be considered as a metastasis unless a primitive tumoural lesion is found elsewhere.

Peritoneal tumours can be cystic (dermoids, lymphangiomas, benign and borderline serous, micropapillary cystadenomas) and solid (serous, micropapillary cystoadenocarcinoma, malignant mesothelioma, small round cell desmoplastic tumour, fibroma, desmoids tumour, and others). Tumours morphology is often non-specific both at US and CT scans; It might appear either solid or cystic depending on the kind of tissue they are made of. In some casese they cannot be distinguished from mesenteric cysts. The more are the solid component and the complex aspect, the more must be the suspect of the mass being malignant.

3. Extra/retro peritoneal originating extra gynaecologic masses

3.1. Urinary system

In pre-ultrasound age was the most frequent pelvic mass the pelvic kidney originating from urinary system, an extremely easy ultrasound diagnosis even in the gynaecologic area. It is also possible that a pelvic supernumerary kidney leads to the same error.

Occasionally, great kidney-originating masses spreading to the pelvic retro peritoneum can simulate reproductive-system tumours; the same goes for huge cysts, or gigantic hydro-

nephrosis. CT scan and MRI can, instead, easily establish the urinary-system origin of the retroperitoneal lesions.

Other causes for urinary-system originating extra-gynaecologic masses are malformations resulting from Müller ducts alterations associated to Wolff ducts malformations. The most frequent are represented by uterus didelfus with blind hemi-vagina. In the latter the mass is constituted of blood and mucus blocking the vagina. There might also originate some pockets of pelvic endometriosis, which are expression of abdominal reflux of vital endometrium. Finally, even an atresic hemi-horn, with or without communicating endometrium, can be a pelvic mass.

A bladder globe might resemble a pelvic mass in patients who underwent radical hysterectomy surgery or radiotherapy which damaged the bladder innervation and caused large stagnation. The bladder can also be site of extrinsic-diffusion tumours, or huge pseudo-diverticula resembling adnexal masses.

The urachus may be a site of inflammatory processes. Cysts are caused by persistence, of the intermediate tract of the urachus, after birth which doesn't communicate with either the bladder or the navel and therefore may house a very slow-growing liquid collection. It appears macroscopically as a spherical, cystic formation with muscular-fibres and urothelium-constituted walls containing clear, citric liquid and urea. It might be an occasional finding during an ultrasonography or a CT exam. The middle position, the front site (between the Linea Alba and the parietal peritoneum) and the round appearance can easily suggest the origin. These cysts, if inflamed, might be confused with pelvic inflammations.

3.2. Alterations of the sacral canal

By these terms are meant malformations of the sacral canal which is the inferior portion of the vertebral canal. In the sacral canal are contained the spinal meninges, the final portion of the cauda equina and the epidural space between the meninges and the bone walls; often such malformations associate with alterations of kidney, bladder and urinary system-growth. The malformation that is most simulating an adnexal pelvic mass is the anterior, sacral meningocele. This is constituted of meningeal herniation through anterior defects of the sacrum-coccyx. They can be either unique or associated with more complex malformations of the terminal thread, as in the caudal regression syndrome, in the generalized mesenchymal dysplasia (neurofibromatosis type 1 or Marfan syndrome).

The mass appears as a simple cyst, homogeneous and anechoic at US.

CT scan, but mainly MRI can precisely detect the origin of the lesion. It is possible to study the alterations of the sacrum, anterior defects, and the whole morphology of the sacrum-coccyx using sagittal reconstruction with CT. The mass is like a simple cyst, with no enhancement and without capsule.

The main signal characteristic is T2 hyperintensity at MRI. Finally, both CT and MRI is able to perfectly detect the neck of the meningocele (Figure 3).

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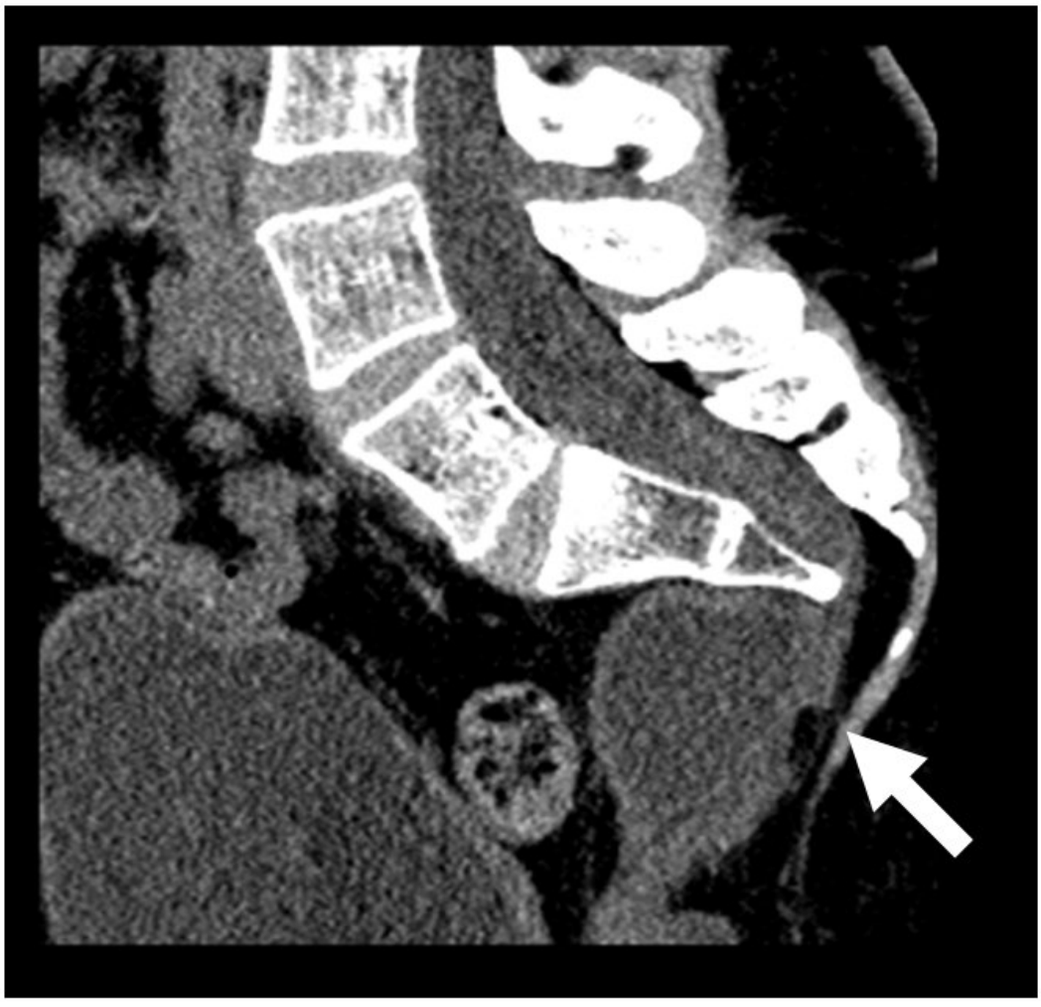

Figure 3. MPR sagittal reconstruction of a CT scan showing an anterior sacral meningocele direcly connected to the medullar canal.

3.3. Pelvic, retroperitoneal tumours

From pelvic retroperitoneum can originate benign or malignant tumours, whose histology might cover all the tissues normally present in the retroperitoneum; mesenchyme: sarcomas, leiomyosarcomas, fibrosarcomas; adipose tissue: lipomas, liposarcomas; nervous system: benign and malignant schwannomas, paragangliomas, neurogenic tumors; hemangiomas: mature and immature teratomas.

The evaluation of these masses is difficult by US. The most preferred techniques are still CT and MRI.

CT imaging appearance is that of a solid mass, only rarely homogeneous in density; it is so mainly as far as neurologic benign tumours (benign schwannomas) or masses rich in well-differentiated striated muscle component (neurofibromas) are concerned. Malignant masses are inhomogeneous, infiltrating the retroperitoneal structures.. Edged and regular contours, the footprint of the surrounding structures without infiltration suggest the benignity.

The masses rich in fatty component, given their retroperitoneal origin, are usually histologically malignant and aggressive; these masses must be distinguished from all pelvic intraperitoneal lipomas. Factors of malignity are represented by the inhomogeneity, the infiltrative character of the edges and the presence of a rich, solid tissue component.

Neurofibromas are solid, neurogenic benign tumours which show enhancement in CT. Both CT and MRI are the first-choice techniques of investigation in the suspect of a pelvic, retroperitoneal mass; this is due to their ability in the topographic localization of the mass and the good ability in the tissue characterization. Probably MRI reaches higher results in the diagnostic accuracy (easy characterization of lipomas, liposarcomas and mature teratomas). If a definitive diagnosis can't be reached by CT or MRI, then guided needle biopsy can be useful. In figure 4 a MRI scan of a schwannoma is presented.

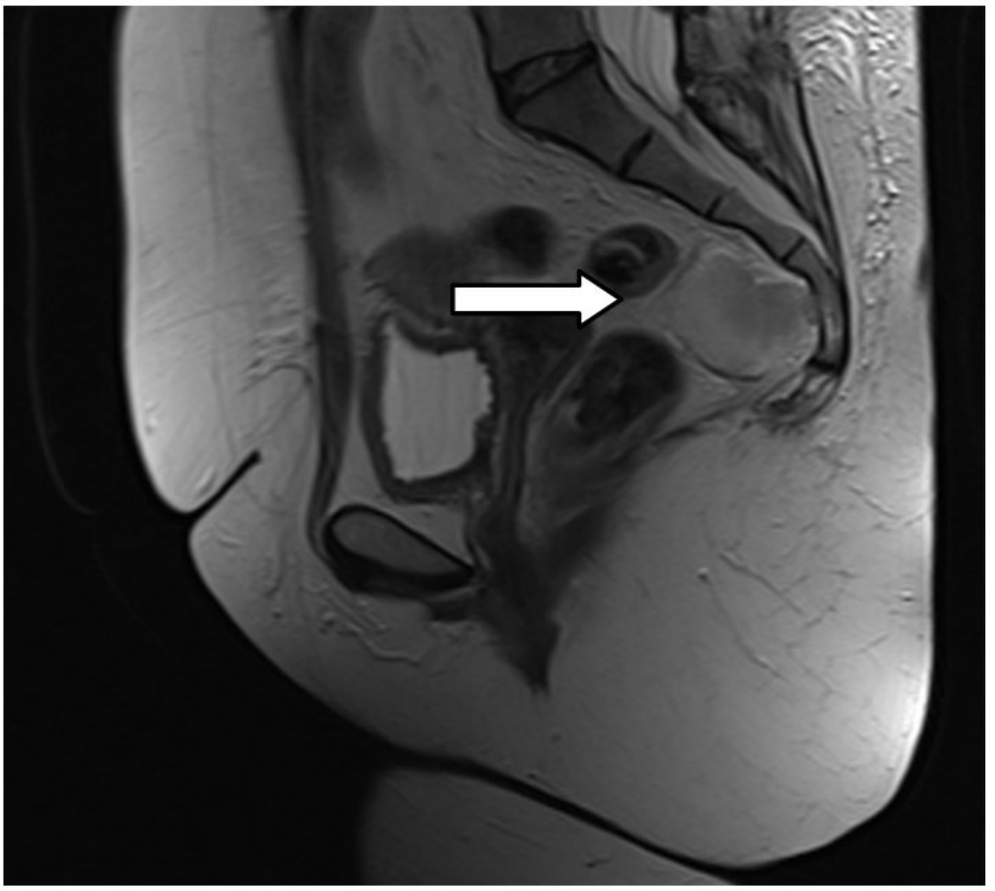

Figure 4. MRI T2-weighted sagittal scan showing a retroperitoneal oval-shaped solid lesion (white arrow) in straight contact with the anterior part of the sacrum, which turned out to be a schwannoma.

They must be considered, finally, other rare, non-gynecological causes for pelvic masses, represented by neoplasias originating from different tissues of the pelvis. We can therefore report some cases of anterior abdominal wall muscles fibromas, pelvic sarcomas, aneurysmal dilatation of the iliac vessels.

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4. Tumoural markers

It has been proved that serum Ca^{125} are helpful in the diagnostic evaluation of pelvic masses, particularly in adnexal masses.

An increase (ranging from 80 to 90%) of Ca^{125} serum levels are associated with ovarian, epithelial, malignant, non-mucinous tumours. Besides, Ca^{125} is related to the volume of the tumour mass. Ca^{125} represents the gold standard tumoural markers for ovarian cancer in two different clinical conditions: as a diagnostic tool for evaluating the risk of malignancy of an adnexal mass and as a monitoring tool in the evaluation of the disease state, in patients already treated for adnexal cancer [7,8].

Ca^{125} serum levels equal or below 35 U/ml are normal. Ca^{125} serum levels greater then 50-65 U/ml (in the 80-90% of postmenopausal patients) is associated with a malignancy. Classifying patients with increased Ca^{125} and a pelvic mass by age, permits a rise in positive predictive value of the association of 80% in patients older then 50 and only 50% in younger ones.

On the other hand this marker increases (in 60-70% of the cases) also in advanced endometrial adenocarcinoma and/or in recurrence.

Other gynaecological malignant solid tumours can increase Ca^{125} serum levels (60% in pancreatic cancer, 20-25% in breast, lung and colon tumours). Other non tumoral conditions can be associated with increased levels of Ca^{125} such as endometriosis, peritonitis, tubo-ovarian abscess, diverticulitis, adenomyosis, uterine fibroids, ascites.

Best specificity and sensitivity results have been reached by integrating different diagnostic techniques like markers and ultrasonography and clinical history to create risk index [9].

5. Gynaecological masses: Assessment of malignity/benignity criteria based upon morphologic and multiparametric ultrasonography

Female pelvic masses are mainly caused by gynaecological diseases. For classificatory purposes it's important to know whether the disease originates from the uterus or from the ovaries. This is often difficult to establish, that's why we tend to use another classification based on malignity/benignity criteria. In this case, the main goal of the radiologist is to characterize the mass from a histological point of view, using different imaging techniques.

The imaging main parameters are:

- size and shape;
- vascularisation;
- associated signs.

As far as size is concerned we can say that the bigger the ovarian mass, the higher is the probability that that mass is malignant.

As far as shape is concerned it must be considered the presence of septa, solid components (papillary excrescences) and mass echogenicity.

The presence of septa highly increases the probability of malignity. This finding becomes more relevant when associated with the thickness of the septa.

The presence of papillary excrescences or solid lesions inside or outside a cystic mass is highly suggesting of malignity.

Ultrasonography permits distinguishing between cystic or solid masses. A certain mass is defined as cystic when the content echogenicity is liquid, with back wall shadowing. On the contrary, a completely solid mass is characterized by more or less homogeneous, multiple internal echoes, giving it a parenchimal-like appearance. Generally speaking it can be said that the higher the echogenicity of a mass the higher the risk of malignity.

In table 3 the most important echographic morphological criteria for the definition of malignancy scores are reported.

Simple ovarian cyst, very likely to be benign:	diameter of less than 5 cm
	thin, smooth walls
	anechoic content
	lack of septa or less than 3, thin septa
	no liquid into the Douglas space
	no solid intracystic vegetations
Complex ovarian cyst likely to be malignant:	diameter greater than 5 cm
	smooth, thick walls
	hypoechoic or solid, homogeneous content
	more than 3 thin septa
	a bit of liquid in the Douglas space
	no solid, intracystic vegetations
Malignant ovarian cyst:	diameter greater than 5 cm
	thick, irregular, nodular walls
	many thick septa
	intracystic, solid component
	intraperitoneal carcinomatosis

Table 3. Echographic morphological criteria for the definition of malignancy scores.

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Morphological scores for the prediction of malignancy of the masses have been made up by ultrasonography.

Historically the parameters evaluated were size (currently it is considered an adnexal mass a lesion with a diameter greater than 4 cm), echogenicity (considering the masses as solid, simple cystic, complex cystic), presence and shape of septa (single or multiple, whether or not associated with vegetating solid components adhering to them), and persistence over time of the tumour.

Since 1974, Kobayashi reported a 70% diagnostic accuracy of ultrasound in the differentiation of ovarian cancer from other pelvic tumours. The presence of papillae, nodules and thickened septa within cysts were elements suggestive of malignant adnexal disease [10]. In 1979 De Land showed how the risk of malignancy increased linearly with the increase of the solid component within the mass [11]. More recently, Hermann, in 1987, classified the pelvic masses into three categories in relation to the morphological complexity: simple cystic forms, complex forms and solid forms [12].

In 1989 Grandberg went another step further, precisely defining others parameters. He defined: the number of the intracystic papillae, the solid, intracystic component percentage and the presence of septa, reporting the malignancy risk percentage for each of those parameters [13].

In 1990 Jacobs tried to introduce a multifactorial score for the diagnosis of malignancy. He did it considering: the gynecological examination, the trans-abdominal ultrasound and the determination of serum Ca^{125}. It was devised an echographic-morphological score assigning the value 1 to each parameter: multiloculated cyst, presence of solid spots, evidence of metastasis, presence of ascites, bilateral adnexal lesions. All these parameters were included in an analysis that showed how statistically significant were the age, the postmenopausal status, the ultrasound score, the Ca^{125} value and the clinical impression. This score has been defined as RMI (risk of malignancy index) [14]. In 1992 Kuriak linked flow metric data obtained by Colour Doppler to the morphologic score proposing a multiparametric score [15].

Recently, in 2011 a new scoring sistem was proposed called Pelvic Masses Score (PMS). It takes into account the Sassone score, the base 10 logarithm of the Ca^{125} level, the central/septal vascular distribution, the menopausal state and the resistance index [15, 16,17].

Currently, morphological scores have been extensively used in clinical practice mainly because they allowed a better morphologic characterization of pelvic masses.

The vascularisation of a pelvic mass is the second element for a diagnosis of malignancy. Once again, ultrasonography represents the first step in the evaluation of this data. The echo color Doppler examination of a pelvic mass has to be performed when there are masses which are strongly suspected to be malignant. Clearly benign masses don't need such ex-

amination. Nevertheless the echo color Doppler examination may be very useful in the interpretation of a mass which isn't clearly benign [15].

The pathogenic factor that justifies the use of colour Doppler in the differential diagnosis of a pelvic mass nature, is represented by the fact that the tumour's new vessels lack a muscular coat, and that causes low resistance to blood flow, generating low Pulsatility Index and Resistive Index values and absence of diastolic notch.

Besides it has to be considered that the flowmeter samples must be multiples and collected from different parts of the mass, that is, not only from the periphery but, more importantly, from the core of the mass. In fact, we believe that many malignant tumours tend to start the new vessel production from the centre of the mass, while peripheral lesion vessels may result from preexisting vessels. A peripheral vascularization of the mass is basically benign, often deriving from ipsilateral uterine artery. Intralesional vascularisation and the presence of vessel in the solid component of the mass or in the septa or papillae, are elements that strongly suggest malignancy. The vascular confluence represents another indication of malignancy [18].

6. Ovarian benign and malignant tumours: Anatomical and pathological classification

Malignant ovarian tumours represent the fifth death cause among US female population; the sixth neoplasia for frequency, the second, most frequent female tumour after endometrial ones and the first death cause as far as gynaecologic tumours are concerned [19].

This illness is more frequent in peri-or post-menopausal women, but there are characteristic histological types for each age group. In adolescents and in women who are younger than 20, half of the tumours comes from germ cells; in post menopausal age they have a most frequent epithelial origin.

The causes for the occurrence of ovarian cancer are not defined; epidemiological studies show that the most affected people by ovarian cancer are represented by peri or post-menopausal, middle or upper class, with no children or just one and with problems in getting pregnant women.

The majority of ovarian tumors begins without well-defined symptoms; as a matter of fact early stages are mostly incidental findings representing just a 20%. In most of the cases they are diagnosed when they are at an advanced stage, that is when the cancer has spread outside the pelvis. The most common symptoms are given by the effect on neighbouring organs: polyuria, dysuria, constipation, sudden increase in abdominal circumference, amenorrhoea, polymenorrhea.

In table 4 WHO histological classification of the tumours of the ovary is presented.

TYPES	SUBTYPES
Surface epithelial-stromal tumours	Serous tumors
	Mucinous tumors
	Endometrioid tumors (including variants with squamous differentiation)
	Clear cell tumours
	Transitional cell tumours
	Squamous cell tumours
	Mixed epithelial tumours (specify components)
	Undifferentiated and unclassified tumours
Sex cord-stromal tumours	Granulosa-stromal cell tumours
	Sertoli-stromal cell tumours
	Sex cord-stromal tumours of mixed or unclassified cell types
	Steroid cell tumours
Germ cell tumours	Primitive germ cell tumours
	Biphasic or triphasic teratoma
	Monodermal teratoma and somatic-type tumours associated with dermoid cysts
	Germ cell sex cord-stromal tumours
Tumours of the rete ovarii	Adenocarcinoma, adenoma, others
Miscellaneous tumours	Small cell carcinoma, Hepatoid carcinoma, Wilms tumours, others
Tumour-like conditions	Luteoma of pregnancy, Stromal hyperthecosis, Stromal hyperplasia, Fibromatosis, others
Lymphoid and haematopoetic tumours	Malignant lymphoma, Leukemia, Plasmacytoma
Secondary tumours	Gastro-intestinal tract (stomach, colon, pancreas), Breast, Renal cell carcinoma, Melanoma, Others

Table 4. WHO histological classification of tumours of the ovary.

7. FIGO staging

Ovarian tumours spread by contiguity, through the intra peritoneal route, by blood and lymphatic. 9% of cases in advanced stage show intra peritoneal carcinomatosis, and 70% ascites.

In table 5 the ovarian tumour FIGO staging is reported [19].

The adnexal masses invasion by contiguity is the direct infiltration of the adjacent anatomical structures. Hence the bladder can be involved through neoplastic deposits in the vesico-uterine fold. The sigma-rectum can also be involved through the rectovesical pouch. In both cases the tumour infiltration very rarely reaches the mucosa.

The intraperitoneal tumour spreading follows the physiologic routes. The most affected sites are: the rectovesical pouch, the para-colic gutters (especially the right one), and the right sub-diaphragmatic peritoneum.

The omentum, through its phagocytic function, collects cancer cells and constitutes an ovarian cancer typical site for cell proliferation. Lymphatic drainage of the ovary in the pelvis and, in the para aortic zone through the infundibulum pelvic ligament, permits the pelvic and lombo-aortic lymphatic metastatic spreading. Neoplastic emboli, reach the left subclavian vein through the thoracic duct, penetrate into the bloodstream and stop in the lung. Pulmonary involvement happens directly through both ovarian veins and the pelvic venous plexus. Upper abdominal metastases (most of the cases liver and spleen) seem to be related to blood-borne neoplastic emboli originating from the sigmoid and superior haemorrhoidal plexus.

STAGE	DESCRIPTION
I	**Tumour limited to ovaries**
IA	one ovary affected, no ascites, absence of capsular infiltration, absence of neoplastic proliferations on the outer surface of the mass;no malignant cells in ascites or peritoneal washings.
IB	Tumour limited to both ovaries; capsule intact, no tumour on ovarian surface; no malignant cells in ascites or peritoneal washings.
IC	Tumour limited to one or both ovaries with any of the following: capsule ruptured, tumour on ovarian surface, malignant cells in ascites or peritoneal washings
II	**Tumour affecting one or both ovaries with pelvic extension**
IA	Extension and/or implants on uterus and/or tube|s|;no malignant cells in ascites or peritoneal washings
IB	Extension to other pelvic tissues; no malignant cells in ascites or peritoneal washings
IC	Pelvic extension (2a or 2b) with malignant cells in ascites or peritoneal washings
III	**Tumour involves one or both ovaries with microscopically confirmed peritoneal metastasis outside the pelvis and/or regional lymph node metastasis**
IIIA	Microscopic peritoneal metastasis beyond pelvis
IIIB	Macroscopic peritoneal metastasis beyond pelvis 2 cm or less in greatest dimension
IIIC	Peritoneal metastasis beyond pelvis more than 2 cm in greatest dimension and/or regional lymph node* metastasis
IV	**Distant metastasis (excludes peritoneal metastasis)** Note: Liver capsule metastasis is T3/stage III, liver parenchymal metastasis M1/stage IV. Pleural effusion must have positive cytology for M1/stage IV.
NOTES	The classification applies to malignant surface epithelial-stromal tumours including those of borderline malignancy. (Non-epithelial ovarian cancers may also be classified using this scheme). *. Regional lymph nodes are the hypogastric (obturator), common iliac, external iliac, lateral sacral, para-aortic, and inguinal nodes.

Table 5. Ovarian tumours FIGO staging

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8. Indications for CT scans and MRI.

The use of CT and of MRI in the preoperative phase of malignant ovarian tumours it's a debated argument even today. A correct diagnosis can be done using only ultrasound, as reported in this chapter. However, it is essential to know the CT and MRI appearance of these tumours mainly because they are easy to compare in investigations performed for other purposes.

In literature there are numerous publications which compare ultrasound, CT and MRI for their ability to distinguish between malignant and benign pelvic masses. The CT reaches a specificity and sensibility of about 92,8 and 88% respectively based on the morphology of the lesions and their vascularization after the injection of Contrast Material [20,21].

In our Institution all MDCT studies were performed using a 64-multislices MDCT system (Somatom Sensation 64, Siemens medical solutions, Forchheim, Germany). MDCT images were obtained from the abdomen and pelvic, covering the area from the diaphragm to the symphysis pubis (craniocaudal). The contrast medium (IOVERSOL 350 mg /ml – Optiray, Covidien Imaging Solutions, Hazelwood, MO) was administered at a dose of 1.5 mL per kg, with a variable flow rate of 3-4 mL per second through the antecubital vein of the right arm.

MRI with paramagnetic contrast Material, on the other hand, not only distinguishes better gynaecological lesions from non-gynaecological ones, but also allows a better tissue characterization of the mass. The CT aspect of an ovarian malignant mass is characteristic though, as ultrasound, it is not able to define the anatomical-pathological variant. The mass can be localized exclusively in the adnexal site or, if size is conspicuous, involve the entire pelvic region. Sometimes, when the whole pelvis is filled with the tumour, it is impossible to make out the adnexal origin. The masses are usually complex with thickened and often nodular walls. Not infrequently there are numerous intralesional septa delimiting different chambers which vary in density and are not communicating with each other. Solid components, usually growing in the liquid section of the mass, are often present at the confluence of the thickened septa. An ovarian cancer very rarely infiltrates the retroperitoneal pelvic structures reaching the bone wall.

Even though it's large and closely adjacent to bladder and bowel, this cancer very rarely fully infiltrates these structures' walls, and if there were infiltrations they'd just involve some peritoneal folds and the rectovesical pouch. The nodular peritoneal dissemination can be correctly evaluated by CT scan in the presence of ascites which facilitates the detection of nodules adhering to the intestinal tract and between the mesenteric sheets. The parenchymal nodules adhering to hepatic peritoneum, gastro-colic, gastro-duodenal and spleno-gastric ligament, are more easily distinguishable. An indirect sign of peritoneal microscopic infiltration is the rigidity of the peritoneal layers taking a radial, rail and fanned aspect. When the omentum is highly involved than it's called "omental cake"finding. The great omentum, which has the function of filtering the free, peritoneal liquid, becomes the site of neoplastic solid metastases, sometimes very large, which often join, forming a neoplastic plaster adherent to the anterior parietal peritoneum [22].

At MRI, the malignant ovarian cancer appears as a big, heterogeneous solid and cystic mass. The solid component shows, in T1, low or intermediate signal intensity, while the intensity is quite high in T2. This aspect, however, can be conditioned by the presence of intra lesional haemorrhagic foci, or areas of necrosis. Also the cystic component of the complex mass can have a different signal behaviour. The malignant cystic, ovarian tumours contain abundant proteinaceous or haemorrhagic material causing a high signal intensity both in T1 and in T2. After intravenous paramagnetic contrast material injection, some thickening of the capsule can also be detected, with the presence of septa or intra-cystic vegetations which can be either associated to the mass solid component or not. By gadolinium administration it is obtained an optimal characterization of the solid components of the complex adnexal mass [23]

Lately, Diffusion weighted Imaging (DWI) as a useful tool to improve the radiological diagnosis of malignant tumors, especially for endometrial and cervical tumours. Concerning ovarian cancer, while initially promising DWI in cystic ovarian tumors proved to be limited, particularly for differentiating benign from malignant lesions [24–25]. In a large retrospective analysis the majority of malignant ovarian tumors, mature cystic teratomas, and endometriomas exhibited abnormal signal intensity on DWI, whereas benign lesions did not. A Few studies addressed the use of DWI for peritoneal dissemination of gynaecological cancer assessment: a high sensitivity (90%) and specificity (95.5%) in evaluation of peritoneal dissemination was proven. Nevertheless, the study population was small [24,25].

Preoperative evaluation of upper abdominal organs by ultrasonography or CT scan is important. At the disease onset, in fact, spleen or liver metastases are frequently found according to the tumour stage [26]. For this reason, staging must always include the study of upper abdominal organs. The intraperitoneal, often multifocal, spread of the ovarian cancer is very frequent and well assessable by both CT and MRI (Figure 5).

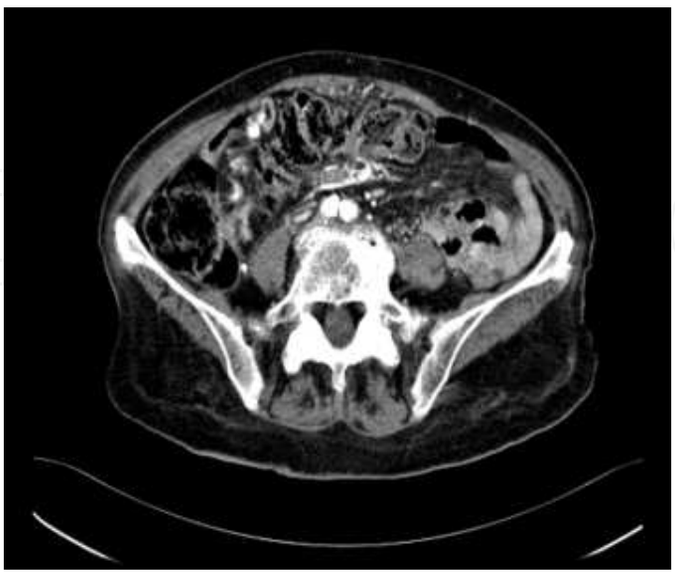

Figure 5. A Contrast Enhanced CT scan showing typical intraperitoneal calcified implants in a serous papillar ovarian cancer (III stage FIGO classification).

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The results of preoperative CT and MRI in advanced stages of ovarian cancer can predict the success of the radical surgery. The residual post-surgery tumor must be absent or of a diameter less than 2 cm. This is a very important goal: in these conditions the patients respond better to chemotherapy and have a more favorable prognosis. Through a quantitative score that examines five common anatomic, frequently affected by the disease sites by CT scan, one can select the patients who are eligible to the initial radical treatment. The criteria for the tumor unresectability include the presence of metastases with a diameter greater than 2 cm localized in the following sites: mesenteric root; gastro-splenic ligament; epiploic pouch; hepatic hilum; hepatic, intrasegmental peritoneal reflection; diaphragm and liver dome. Besides other unresectability criteria are: lymphadenopathy greater than 1 cm above the celiac zone; presence of extraperitoneal, presacral disease [26].

9. Adnexal inflammation, tubo-ovarian abscesses and Pelvic Inflammatory Disease (PID)

By the term PID it's meant female genitalia inflammations not only affecting reproductive organs but also the whole pelvic zone, including the pelvic peritoneum. From a pathogenetic point of view PID includes primary and secondary forms, representing In the primary forms, which represent more than 90% of the cases, the inflammation affects initially the lower genital tract (cervico-vaginal tract), spreading subsequently to the uterus, the adnexal glands up to the pelvic peritoneum. In the pathogenesis exogenous factors are involved of such as sexually transmitted germs and instrumental factors; or endogenous factors as in the case of the pathological transformation of cervico-vaginal saprophyte flora. The secondary forms,which are quite rare, are determined from the diffusion to the internal genitalia, through blood, lymphatic or by contiguity, of pathogenic microorganisms from extragenital outbreaks: pyelitis, cysto-pyelitis, cystitis, colitis but especially appendicitis, peri-appendiceal abscess, diverticulitis.

For each pathogenic PID form there have been recognized risk factors. In the case of the primitive exogenous venereal PID they are represented by the young age, frequency and precocity of sexual relationships, number of partners and sex during the menstrual phase.

In the case of primitives exogenous iatrogenic PIDs the most important risk factors are: the use of intrauterine devices (IUD), voluntary termination of pregnancy, endometrial biopsies, hysteroscopy, hysterosalpingography and tubal insufflation. The PID aetiology needs to be continuously updated. It is currently considered to be poly-microbial. We assisted to a reduction of the pathogenic role of Neisseria gonorreae down to 15-20% compared to association of both aerobic and anaerobic germs: streptococci, staphylococci, E.Coli (10-40%); Mycoplasma (10-30%), Chlamydia trachomatis (40-60%). PID includes several pelvic diseases clinically distinguishable into acute and chronic forms. Acute infections are caused by uterine cervical flora that spreads from the mucosal surface to the uterus and fallopian tubes, finally affecting the pelvic and/or abdominal peritoneum. The subacute and chronic form widely varies in extension and severity, including tubal lesions with the formation of

pelvic liquid collections and connectival reaction widespread, or by formation of extensive and tenacious adhesions. In order to have an accurate and early PID diagnosis it is essential to the use of imaging techniques. Laparoscopy is essential not only for recognizing the disease but also in order to isolate the pathogenic germs, favouring a targeted therapy.

Based on the laparoscopic findings there are three distinct forms of acute salpingitis, each with different prognostic significance:

- light form: the tubes are hyperemic, edematous, covered with exudate or by deposits of fibrin, but are mobile and with patent ostia;
- moderate form: the signs are more evident and there are doubts about the ostia patency;
- serious form: there is pelvic and peritoneal inflamnation with closed ostia and/or abscess formation.

Ultrasonography was used to confirm the pelvic abscess clinical diagnosis, thanks to its accuracy, sensitivity and specificity. Compared to laparoscophy, endovaginal ultrasonography can recognize almost all of the cases of severe tubal damage, but just 65% of slight tubal damage. Ultrasonography is also very helpful in the follow-up of pelvic inflammation patients, for evaluating the effectiveness of therapy.

On the other hand ultrasonography may be negative both in the acute and in chronic salpingitis. In PID detection of some liquid into the recto-vescical pouch, it may result easy with US, and it may have a higher diagnostic value whenever the liquid presented diffuse or inhomogeneous echogenicity, indicating a blood or purulent collection.

CT scan is not so useful as far as mild and moderate forms are concerned; it's crucial in the recognition and evaluation of the chronic PID.

MRI seems to be very useful in the diagnosis of this disease; it is in fact possible to characterize the inflammation activity, better distinguishing the acute state from the subacute and chronic ones.

The salpingitis initial phase, which is characterized by hyperemia and edema, can be laparoscopically evaluated but not by ultrasound, CT scan and MRI. However, it is a very short lasting phase and is rarely demonstrated even by a early laparoscopy. Salpingitis often follows and is associated with endometritis which can be sonographically demonstrated: the uterus is large, with loss of normal endometrial echogenicity and with irregular, undefined borders; sometimes the cavity may contain hypoechoic material. Even CT scan and MRI don't show, at this stage, any ovarian alterations, while in the presence of endometritis nonspecific uterine abnormalities can be detected: hyper- hypodense endocavitary formations (due to liquid collections) with no enhancement after CM injection.

In the exudative phase, exudate collects in the tubes, covers the fimbrial peritoneum and can spill out of the still open tubal ostium, or, when it's closed, the tubes stretch and become filled with exudate (laparoscopically moderate or severe PID).

By ultrasound, adnexal region appears magnified, with well-defined contours and with a cystic appearance; begins to form a multilobed, often multisepted, sausage-like mass. The

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content can be more or less echogenic depending on the blood or exudative component. In some cases of this last condition some pseudo-niches determined by thickening of the tubal mucosa are observable inside the dilated tube.

By CT scan the adnexal region may appear swollen and inhomogeneous; after the CM administration it can be highlighted a marginal rim of intense enhancement delimiting the various ectatic portions of the tube. The pious-sactosalpinge has a more or less folded intestinal-like appearance and by this feature it can be distinguished from other ovarian liquid formations; the density is varying from serous to corpuscular (Figure 6).

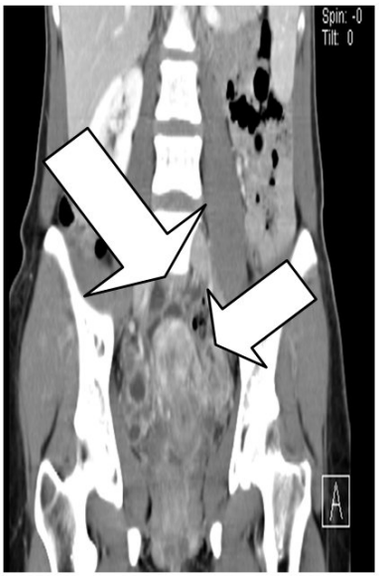

Figure 6. MPR coronal reconstruction of a Contrast Enhanced CT scan during portal phase showing bilateral swelling of the tubes which have an intestinal like appearance in a sactosalpingitis (white arrows).

If an early therapy it hasn't been established, the next step of the inflammation involves the involvement of the ovary. The bag filled with pus extend the the fallopian tubes and ovarian parenchyma making them lose their cleavage planes, wrapped by tenacious adhesions. The tubo-ovarian abscess rupture (3.5%) is a surgical emergency. The tubo-ovarian abscess appears as an adexal or retro-uterine mass, often with internal baffles and sometimes images of gaseous levels. During the appropriate antibiotic treatment the mass becomes better defined and cystic. It can often be found some liquid into the recto-vescical pouch and endo uterine abnormalities can coexist. The echo color Doppler may be helpful in the mass characterization. The hyperaemia and angiogenesis caused by acute inflammation result in an increase of both systolic and diastolic flow velocity, with decreased PI and RI. These altered flow conditions may be reversible during the gradual disappearing of the inflammation. The differential diagnosis must consider the acute salpingitis with sactosalpinx, the tubarian piocele, other conditions of chronic pelvic inflammation without masses.

CT scan, at this stage, detects the adnexal or retro-uterine mass. After CM administration, in the most acute forms, may be evident an intensely enhanced, marginal rim, which is a typi-

cal sign of ongoing inflammation. In the acute and sometimes even in chronicle forms the central part of the swelling presents various densities but not contrast enhancement; sometimes there are baffles which delimit internal chambers. In chronic forms the mass may present irregular contours, inhomogeneous density and contrast enhancement.

In neglected cases and in those which do not respond to treatment, the inflammation extends to the entire pelvic peritoneum, the bowel, the contralateral ovary, the bladder and the ureters. The anatomical-pathological framework includes peritoneal inflamnation, distant abscesses and, in the chronicle evolution, adhesions between peritoneal organs, inflammatory infiltration of the peritoneum and retroperitoneal tracts.

By ultrasonography, the pelvis appears very irregular showing ill-defined, irregular contoured masses with both solid and liquid component; under these conditions, the uterus and the ovaries can be indistinguishable. It can be associated, in this framework, hydroureteronephrosis.

CT scan easily recognizes the pelvis structural-anatomical upheaval. By CT scan/MRI certain signs are very obvious which, if present, provide an accurate picture of the disease severity. These signs are: fascial and peritoneal thickening; peri-rectal, peri-vescical, intestinal, pre-sacral, pre-vescical and latero-pelvic fat's increase in density and inhomogeneities; involvement of extra-genital structures; masses that can be dumped to the uterus, may spread to the recto-vescical pouch and to the parametrium. The contours are irregular and hazy [27].

MRI seems to play an important role in the diagnosis of pelvic inflammation as can be used in the initial phase of the disease (the exudative one), or in the tubo-ovarian abscess and pelvic peritonitis. By MRI, the tubo-ovarian abscess appears as a simple or complex cystic mass, with irregular but neat and well defined walls. The cystic component has signal intensity similar or modestly higher than fluid one (low T1 signal and high T2 one); only rarely it may present a high protein content and therefore a blood-like signal (Figure 7).

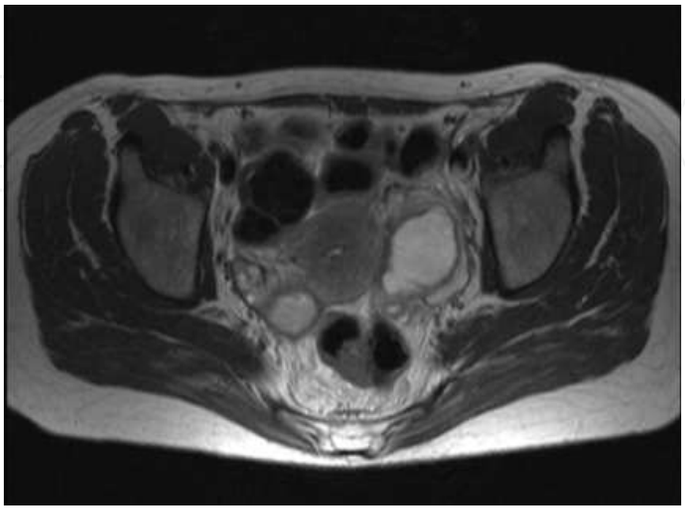

Figure 7. Axial MR scan of a bilateral acute salpingitis. Huge dilatation and bilateral swelling of the tubes can be seen.

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10. Metastatic tumours

Ovarian metastatic tumours are quite frequent: they are about 5-10% in the US, and 15-18% in Japan. On Imaging it has to be always considered the possibility of a metastatic tumour whenever a pelvic mass is found. Nevertheless is has been observed that even using all the different imaging methods and machines they can't differentiate with certainty a primary pelvic mass from a secondary one. Both by ultrasonography and CT scan have been described the Krukenberg tumours whose pattern may greatly vary. The common gastric Krukenberg presents a solid, homogeneous, bilateral mass pattern (Figure 8), while the metastasis from colon-rectum have a more often cystic, complex, necrotic pattern.

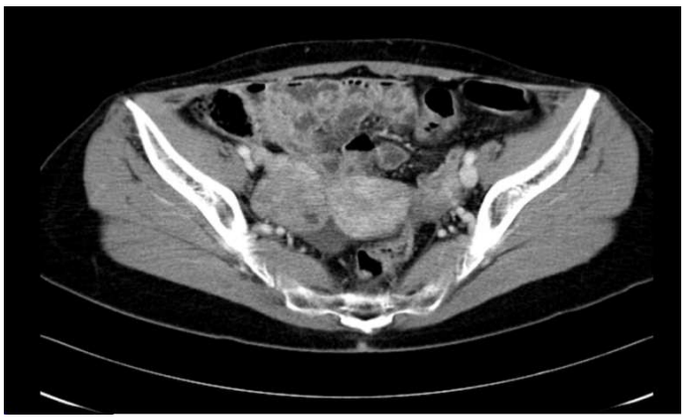

Figure 8. Contrast enhanced CT during portal phase showing two heterogeneously enhanced round masses in a patient suffering from gastric cancer. Histology of the resected masses showed signet-ring cells consistent with Krukenberg metastases.

At US gastric Krukenberg tumours can be bilateral, consisting of complex masses with different percentages of solid and cystic components, frequently associated with ascites. At CT scan Krukenberg tumours are described as mainly solid, with rich peripheral C. E., with cystic component in the cortical or intralesional site masses. The cystic components' walls present a high C.E.

At MRI It is represented by a solid, T2 hypointense, consisting of dense stromal tissue component. It has been than observed that when an apparently malignant adnexal mass is bilateral, shows well defined but irregular contours, is associated with peritoneal carcinomatosis without ascites, it is 7 times more likely to be a Krunenberg than a primary ovarian tumor.

11. Cystic ovarian teratomas

Mature cystic ovarian teratomas are benign tumours recognisable, using various imaging techniques, by certain characteristics. Already from direct examination of the pelvis, it is

possible to obtain very clear images showing teeth-like characteristics, either singular or grouped from a common germinal follicle.

The appearance of dermoid cysts at US is highly variable and depends on the homogeneity and composition of the newly formed tissue. The calcifications inside the mass, characterised by acoustic barriers, are not, however, pathognomonic, as they are also seen in other benign tumours (Brenner) or in malignant adnexal masses. Similar images can be also frequently observed in teratomas and it is possible to recognise not only the Rokitansky protuberance, but also the presence of skin appendages, locks of hair, sebum and glands. The fatty component can also present crude images indicating acoustic barriers, located within a fluid; this is due to varying acoustic impedance of different fat components.

The ultrasound morphology of the mass can be that of a homogenous formation, with elevated echogenicity and a solid appearance; on the other hand it can appear as a cystic formation, either simple or complex depending on the acoustic impedance of the intralesional structures. In some cases, the ultrasound cannot provide a definite diagnosis of teratoma and in others it cannot exclude malignant characteristics.

In CT scans however, the appearance of dermoid cysts is often pathognomonic. CT is the ideal method to evaluate tissue fatty components, leading to a correct diagnosis in case of adnexal fatty mass. Even when other hypodense tissue, like sebum and hair, are present, the fat is recognisable and the, usually, polymorphic appearance in the ultrasound is defined more clearly. CT scans can also correctly identify calcification, better define their morphology and therefore reach a diagnosis. In CT scans it is also very easy to identify fat buoyancy, a pathognomonic sign of dermoid cysts (Figure 9).

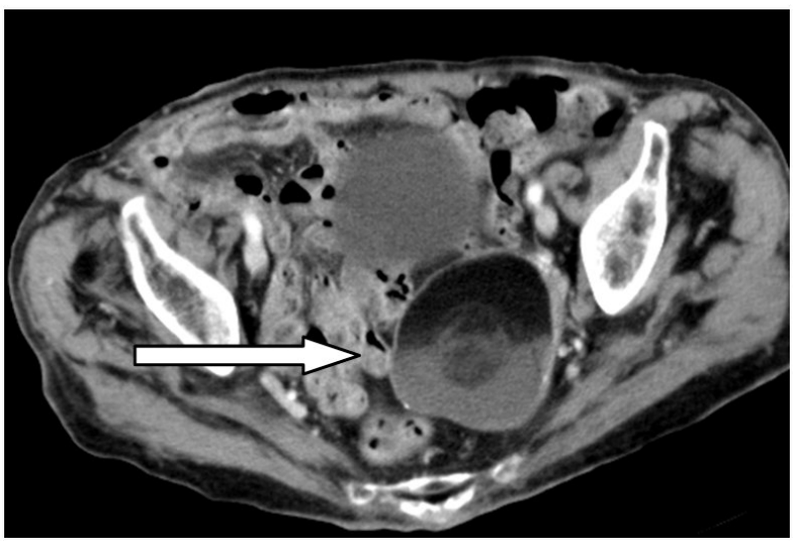

Figure 9. A Contrast Enhanced CT scan showing a huge lesion in the left hemipelvis (white arrow). A fluid –fat level can be seen within the lesion; there is a heterogeneous floating part with soft tissue density. This lesion turned out to be a dermoid cyst.

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Even in magnetic resonance imaging (MRI) the diagnosis of dermoid cysts is based on the evidence of fat within the lesion. T1 and T2 weighted images are not enough for this purpose and so fat suppression techniques need to be implemented (Figure 10).

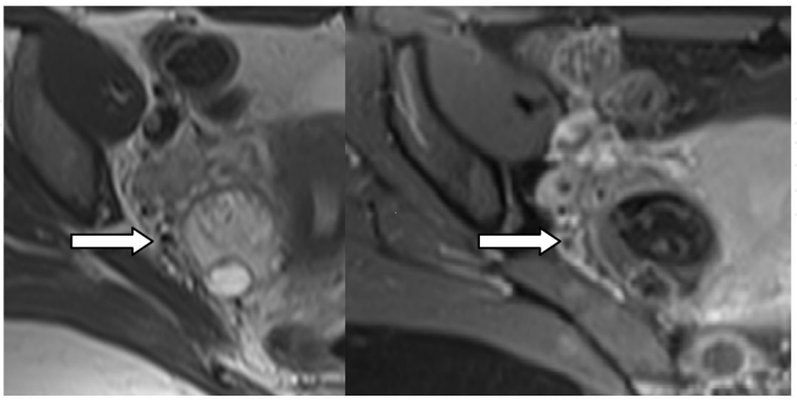

Figure 10. T2-weighted images non-fat saturated (left picture) with fat saturation (right picture) in a MRI scan of a patient with a pelvic mass (white arrow), showing a heterogeneous mass in the left ovary in which there is a signal drop in fat saturated image. The mass proved to be a dermoid cyst.

A differential diagnosis is necessary for endometriotic and mucinous cysts. Diagnostic difficulties may arise when there is a small fat component, or a high levels of hematic content that masks the fatty signals. MRI can correctly evaluate fatty levels and fat buoyancy components, like the Rokitansky nodule; these semiological aspects help differentiate diagnosis. Chemical shift artifacts caused by the presence of fat are also useful in the diagnosis of dermoid cysts. Intravenous administration of gadolinium causes contrast enhancement of the cyst walls and of the Rokitansky nodule [28,29].

Mature teratomas are, in most cases, benign tumours; on occasion, there may be an immature component, with malignant characteristics; this occurs in about 1% of all benign teratomas. The tumour most commonly associated with the teratoma is the squamous-cell carcinoma.

Malignancy signs in a dermoid are indicated by tissue showing clear enhancement. In addition, as the malignant component often infiltrates different dermoid tissues, the capsule, or the extracapsular anatomic structures, it is possible to assess the nature of the cyst by its aggressive morphological appearance. Complications of cystic dermoids are represented by ovarian torsion, or by acute rupture of the mass in the peritoneum.

It is also important to remember that a dysontogenetic pelvic mass may not necessarily originate from the ovary. Sacrococcygeal teratoma and primary retroperitoneal teratomas are more frequent. Sacrococcygeal teratomas are most common dysontogenetic masses in infants; the diagnosis can also be done in uterus, with direct ultrasound visualisation of a presacral mass often associated with polyhydramnios. In many cases the masses are visible externally, developing in the subcutaneous tissue of the intergluteal area;

The masses can have macroscopic appearances, ranging from predominantly cystic, to mixed, to predominantly solid; the last one is most likely to be malignant.

Imaging plays an important role in the diagnosis of these tumours: firstly, through CT ad MRI scans it is possible to differentiate between other abnormalities of the terminal filum such as meningocele and myelomeningocele. It is possible to identify other abnormalities also associated with teratomas in the sacrococcygeal area. Rarely it's possible to observe the growth into the vertebral canal or bone destruction due to teratoma. The association with anal stenosis, vesicoureteral reflux, presacral abscess and skin changes may be indicative of Currarino syndrome.

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