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# Diagnostic approach to adnexal lesions in young females in their second and third decades

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## Abstract

**Background** To review the imaging options and features of different ovarian lesions in young females. We also aimed to put a simple approach to reach the appropriate diagnosis.

**Patients and methods** A retrospective study of 120 patients were included in their second and third decades. All cases had examined by ultrasound then other preferred imaging modalities were used either CT or MRI to reach the appropriate diagnosis. Further, serological and pathological assessments were done in some cases.

**Results** Ovarian pathologies were 89.1% and extra-ovarian adnexal lesions were 10.8%. Non-tumoral ovarian pathologies were the upper hand in both decades, followed by benign tumors in the first decade; however, the overall malignancy was common in the second decade. The ultrasound provided substantial proof of the diagnosis in 34.1% without further need for advanced imaging with a sensitivity and specificity of 100% besides it helped in the discrimination between benignity and malignancy of the ovarian tumors with calculated overall sensitivity and specificity of 93.7 and 88%, respectively. MRI and DWI have raised the sensitivity and specificity up to 95.4% and 96.3% respectively in the setting of ovarian tumor's nature discrimination.

**Conclusions** The majority of adnexal lesions were benign in this age group. It was not always possible to distinguish between benign and malignant adnexal tumors using ultrasound only, so adding CT and /or MRI for more characterization of some lesions raises the diagnostic performance of the diagnosis to achieve proper management for saving fertility and crucial when ovarian cancer discovered to help adjuvant therapy and enhance patient outcomes.

**Keywords** Diagnostic approach, Adnexal lesions, Young females

## Background

In the young female population, adnexal anomalies are uncommon but not infrequent. The adnexal width illness seen in adult women is observed in younger age group, even though different in terms of incidence profile. The diagnosis could be delayed or more challenging due to a low index of suspicion, or missing; general complaints [1] (Fig. 1).

Pediatric and adolescent adnexal masses are similar to adult cases and may be physiologic, para tubal, tubal, or neoplastic origins with the potential for benign, malignant, or borderline malignancy. Infection (such as tubo-ovarian abscesses, pyosalpinges, or hydrosalpinges). Pregnancy can also cause masses such as ectopic pregnancies, functional cysts, corpus luteum cysts, endometrioma, mature cystic teratoma, and cystadenoma. Other organ-related disorders must also be considered like appendicitis/appendicular abscess, peritoneal/

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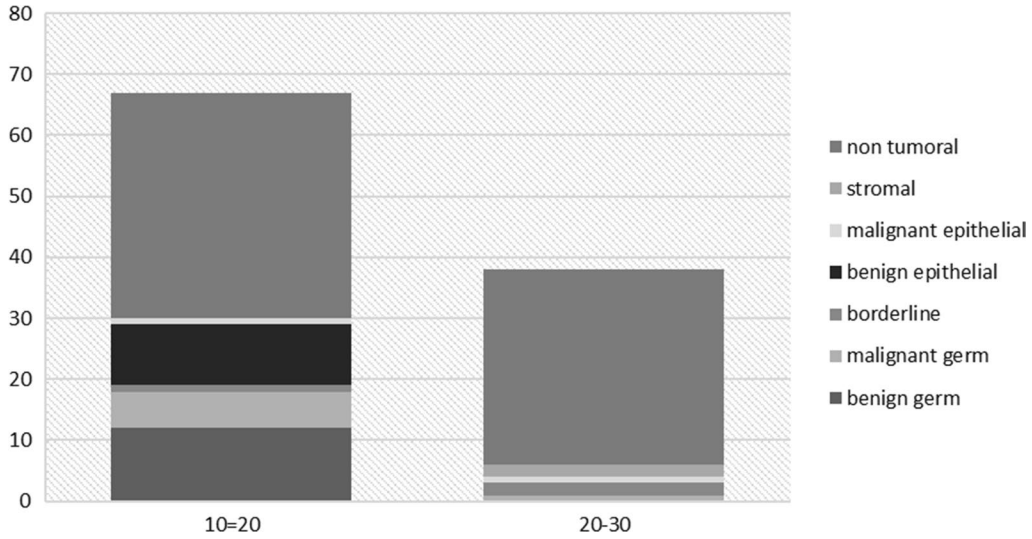


**Fig. 1** Distribution of ovarian lesions in relation to age group

retroperitoneal inclusion cysts, and renal ectopy/urological anomalies [2].

Ovarian tumors are infrequent in young females. But up to 10% of adnexal tumors are cancerous. The World Health Organization has divided these tumors into three primary categories based on whether they originate from sex cord-stromal tumors, germ cells, or epithelial cells. In lymphomas or leukemias, there is a possibility of primary or secondary locations. To lower morbidity and mortality and, more critically and maintain fertility, it is essential to distinguish benign from malignant tumors and reach the appropriate diagnosis quickly [3].

Ovarian lesions can present in a variety of ways clinically, but they typically cause lower abdominal pain or a palpable lump. When aggravated by torsion, rupture, or bleeding, it can occasionally become acute. Patients who experience episodic torsion may also experience sporadic pain; if the tumor secretes sex hormones, precocious puberty or virilization may be the presenting symptom; adolescent girls may experience menstrual irregularity manifested by hypermenorrhea or amenorrhea [4].

Alpha-fetoprotein (AFP), beta-human chorionic gonadotropin (B-HCG), CA-125, and lactate dehydrogenase are the most helpful serologic tumor markers (LDH). Only 50% of malignant lesions had elevated serum levels of AFP or B-HCG, despite the fact that these markers are strongly suggestive of malignancy [5].

For the initial evaluation of adnexal lesions, due to its reduced price, widespread availability, dynamic real-time nature, and absence of ionizing radiation, ultrasonography (US) is the preferred modality. The more thorough endovaginal examination is less suitable for most children and adolescents than the transabdominal US, which uses the bladder as an acoustic window. In sexually active teenagers, the endovaginal US is taken into consideration after an unsuccessful transabdominal examination [6].

MRI and CT are both helpful tools for evaluating adnexal masses in addition to the US, MRI was selected as the second-line diagnostic method because it provides a higher soft tissue resolution. Due to its ability to thoroughly examine the pelvic side wall and surrounding organs for involvement, MRI is more beneficial than CT for further identifying ovarian masses and for the locoregional staging of malignant tumors. It is more challenging to complete the MR imaging test in emergency cases because it takes longer and younger patients may require anesthesia [7].

In addition to detecting acute symptoms, CT is the preferred scan for determining dissemination to distant organs. To help expand and opacify the intestine during CT scans, oral contrast can be given in addition to intravenous contrast, as a non-opacified gut can simulate cystic adnexal diseases [8]. Additionally, it can be challenging to distinguish ovaries from non-opacified bowel loops in slender children. However, for a variety of reasons, the updated research has disputed the advantages of oral contrast during abdominal and pelvic CT scans. The requirement for sedation and the radiation danger should be considered while deciding between an MRI and a CT scan [9].

This study's objective was to review the imaging options and features of different ovarian lesions in young females in addition to their clinical and pathologic findings. We also aimed to put a simple approach to reach the appropriate diagnosis as the spectrum of adnexal lesions is very wide including neoplasms, vascular compromise,

infection, and some important para-ovarian mimickers as a differential diagnosis as shown in Fig. 2.

## Methods

This retrospective study was done in the radiology department (women's imaging unit) from January 2020 to April 2023. The Ethical committee of the institutional review board gave their approval for the work. Parents of

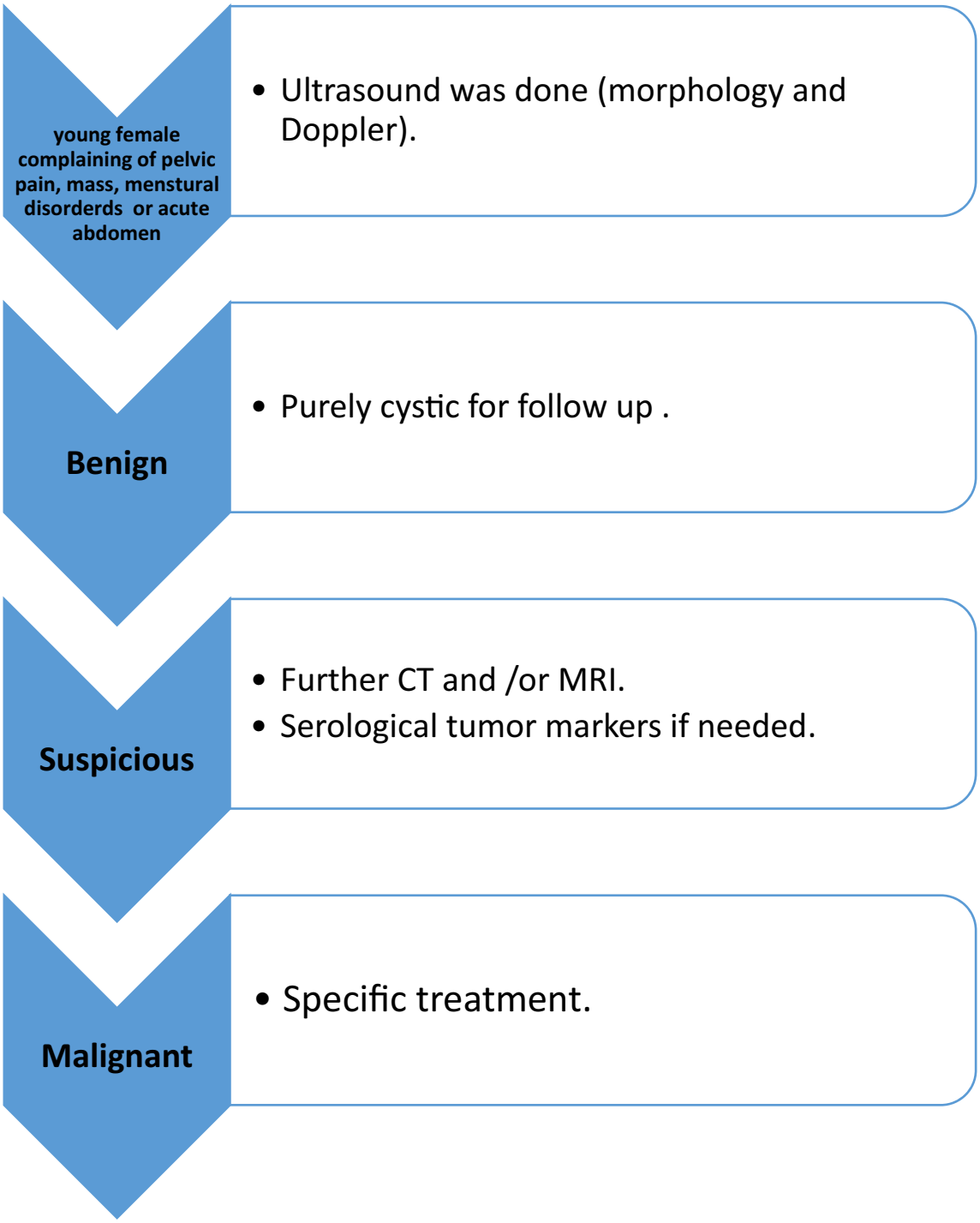


**Fig. 2** An algorithmic approach to adnexal lesion

children and adult patients had provided their informed consent.

The inclusion criteria were

A. The age range (11–30) at diagnosis;
B. Initial pretreatment imaging (ultrasound, CT, or MRI) is provided for analysis.
C. Each lesion's specific pathological diagnosis.
D. The following clinical data were obtained:
   1. Age at diagnosis. 2. Age of puberty and menarche status. 3. Full medical history and detailed presenting symptoms (onset, duration, pattern). 4. Serum levels of serological tumor markers. 5. Date, surgical method (laparotomy vs. laparoscopy), procedure (such as a cystectomy, oophorectomy, or detorsion), and adnexal torsion or tumor rupture for patients who underwent operative management 6. For patients in whom conservative care was used, repeated ultrasound examination dates and results were recorded along with the recommendation of hormone therapy for the treatment of ovarian cysts.
E. In our study, different imaging modalities were entitled to the study group (US, CT, and MRI) with nearly all participants being examined by the US as an initial modality.
F. The decision for advanced imaging tools either CT or MRI to reach the diagnosis of the lesions was dependent on the nature and components of the lesions seen by the initial US study. In the case of ovarian lesions, we followed the most recent US classification of ovarian lesions; the O-RADS risk stratification and management system by the American College of Radiology [10] were applied to standardize and define the ovarian lesions.
G. MRI was done for better soft tissue characterization and to study the dynamic pattern of O-RADS 3 to 5 described ovarian lesions giving their score for identification of either benignity or malignancy. On the other hand, CT was preferable to detect lesions with fat, calcifications contents, cases of surgical emergencies such as rupture, pelvic infection, staging before surgery and restaging following debulking of the malignant tumors, and to detect peritoneal implant.

### Techniques of different imaging modalities

- US examination was carried out by a specialist experienced in gynecological ultrasonography for at least 10 years. (General Electric, New York City, USA, Voluson Pro 700). a 5.0–7.0-MHz transabdominal probe was used.
- The following were the detailed specifications for CT acquisition using a 32-channel multi-detector CT scan er (GE): tube voltage: 120–160 kVp standard tube current (60–120 mAs). 3.0 mm slice thickness 1.0–3.0 mm reconstruction interval. Patient in the supine position, pre-, and post-contrast with axial and sagittal reconstruction. Both oral and intravenously administration of contrast material was used (for IV; 100–145 mL of 60% iodinated intravenous contrast material at a rate of 1.5–2 mL/sec with an 80–90 s scan delay) and (for oral; 2% iodinated water-soluble contrast material or 2.1 percent wt/vol barium sulfate suspension). From the iliac crests to the pubic symphysis, images are collected.
- The MRI was performed on a 1.5 T Siemens MAGNETOM Avanto machine with a 60 cm bore size, 160 cm system length, and Zero Helium boil-off technology. 256 × 256 matrix, 32 cm field of view, and 4mm slice thickness were used to create axial pictures. The patient is lying down. Turbo spin-echo sagittal, transverse T2-weighted, transverse T1-weighted, and brief T1 inversion recovery (STIR). Fat-suppressed T1W sequences were also obtained before and after intravenous gadolinium infusion (0.2 mL/kg (0.1 mmol/ kg) at a rate of 10 mL per 15 s), and contrast dynamic findings were analyzed through three different approaches: descriptive, semi-quantitative, and quantitative. Diffusion-weighted imaging (DWI) was done at both low and high b values > b800. The pictures were then transferred to a different workstation where they were analyzed, edited, and rebuilt in the axial, coronal, and sagittal planes

### Image interpretation

- Finding the origin of the lesion was one of the imaging requirements either ovarian, tubal, or extra-ovarian.
- If unilateral, bilateral, unilateral, or multiple lesions (Fig. 3).
- The mass's size at its maximum diameters.
- The nature of the lesion either solid, cystic (uni or multilocular), or complex solid/cystic (Fig. 4).
- The existence of mural nodules/ papillary projections, intra-tumoral fat, blood, or tumoral calcifications
- If there was or was not vascularization/enhancement of the lesion.
- Related aberrant endometrial thickening (greater than 15 mm thick in postpubescent individuals, or more than 10 mm thick in prepubescent children, suggesting an unusually pubescent uterus).
- Ascites if present.

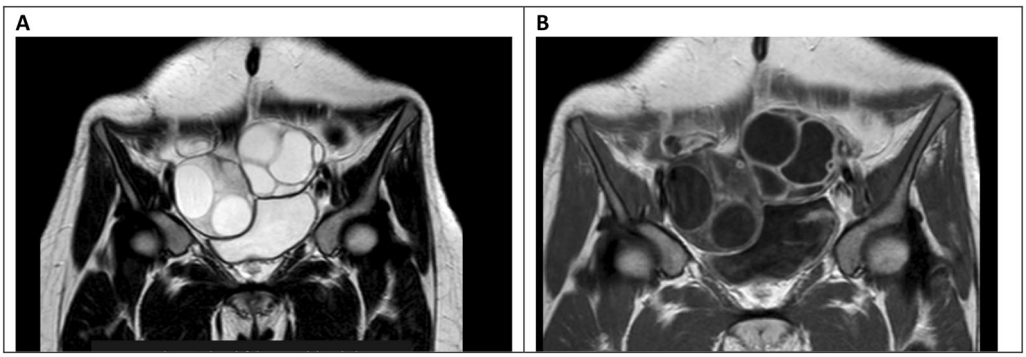


**Fig. 3** A 23-year-old female was presented with bilateral enlarged ovaries. On MRI: **A.** T2 coronal shows bilateral multicystic ovaries. **B.** on dynamic post-contrast faintly enhancing strauma with type 1 curve. The patient was on hormonal treatment for menstrual irregularities denoting hyperstimulation

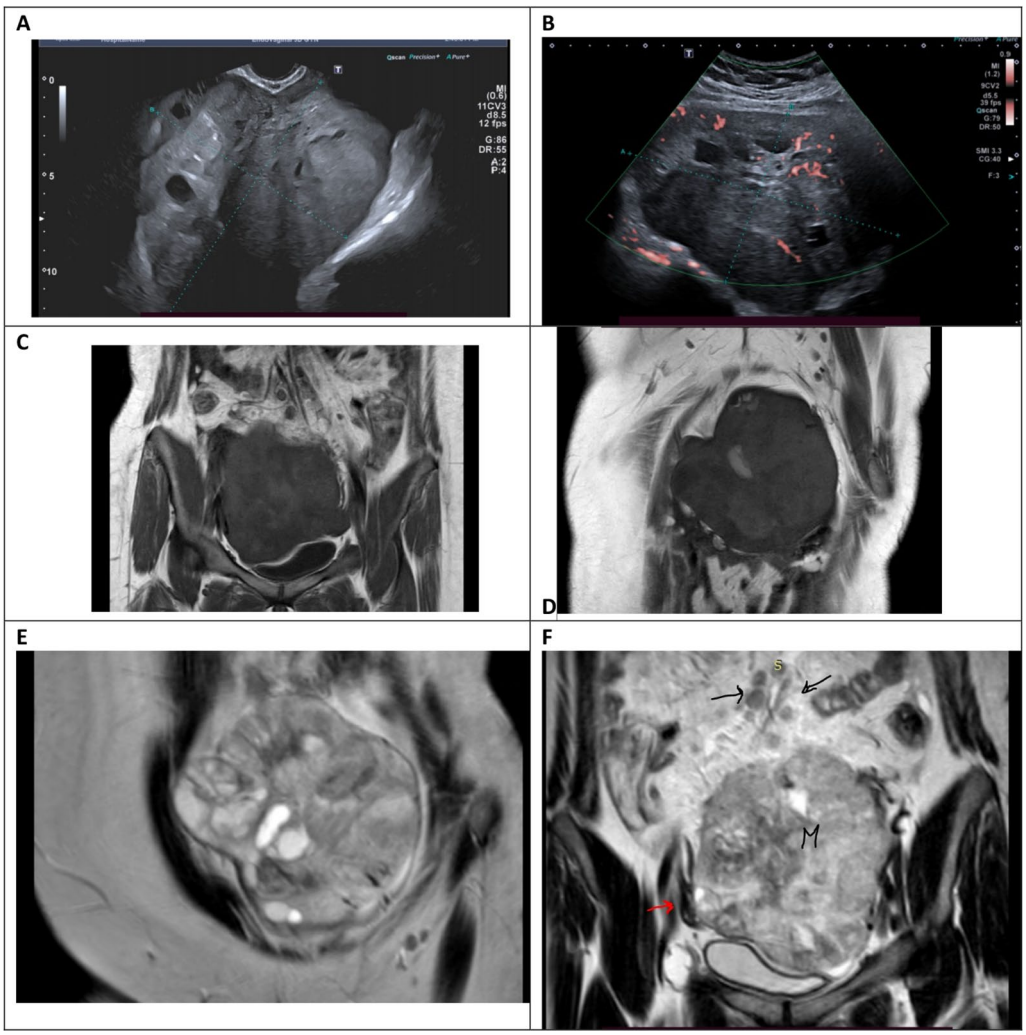


**Fig. 4** A 22-year-old female patient presented with abdominal distension (**A** and **B**). The left ovary is grossly enlarged and replaced with a heterogeneous, hyperechoic mass with multiple cystic areas within it. The mass contains extensive internal vascularity. MRI images, coronal and sagittal T1 (**C** and **D**), and sagittal T2 (**E**) showing a solid-cystic mass in the lower abdominal-pelvic region is not seen separately from the left ovary. It is of variable signal intensity with multiple solid areas noted within it. Central areas of fluid are seen coronal T2 images (**F**) showed replaced normal right ovary (red arrow) as well as multiple para-aortic lymph nodes. The AFP was highly elevated, so an ovarian yolk sac tumor was highly suggested which was confirmed also by pathology

- Any extra-ovarian growth (peritoneum, lymph nodes, or bowel wall thickening in case of Krukenberg tumor) (Figs. 5, 6).
- Ovarian lesions were classified as benign, borderline, or malignant. The presence of solid components/vegetation with intermediate T2 signal intensity, a solid component with high signal intensity on DW, a solid vascular/enhanced component with a type 3-time signal intensity curve, a mass larger than 12 cm, voluminous ascites, any extra-ovarian extension (peritoneum, lymph nodes), and elevated serum tumoral markers as AFP, β-hCG, LDH, inhibin, and CA-125 were all favorable imaging characteristics for malignancy.
- All radiologically diagnosed adnexal lesions in the study group were correlated to histopathological and laboratory results.

We entitled an algorithmic pathway for easier identification and diagnosis of adnexal lesions in the 2nd and 3rd decades of life as shown in the figure.

#### Statistical analysis and sample size calculation

The sample size equation was used to determine the sample size for sensitivity and specificity detection with the anticipated sensitivity and specificity being 89% and 82%, respectively. The sample size was calculated as study group *N*=120, disease prevalence 20%, precision 20%, confidence interval 95%, and level of significance 0.05. The analysis was carried out using social science tools (IBM Corp., Armonk, NY, USA). The mean and standard deviation were utilized for quantitative variables, while frequencies (the number of occurrences) and relative frequencies (percentages) were used for categorical variables. The sensitivities of several imaging modalities were calculated. When comparing numerical variables for independent groups that were not normally distributed, the Mann-Whitney U test was employed. Categorical data were compared using the Chi-square test or Fisher's exact test. $P \leq 0.05$ was considered to be significant.

## Results

In our study, 120 female patients with adnexal masses were evaluated. The age range of the patients was from 10 to 30 (mean age 15 ± 8.6SD).

The most typical presentation in our study was abdominal distension/pain and the appearance of a palpable mass 66 (55%). Fourteen patients (11.6%) presented with the clinical signs of acute abdomen; seven were associated with torsion, two cases of pelvic infection, and five cases presented at surgical procedure with adnexal rupture. The nineteen cases (15.8%) with fever, nausea, and vomiting corresponded to four cases of pelvic infection, four ovarian pathologies (teratomas and simple ovarian cysts) associated with torsion, five malignant tumors with signs of necrosis on histology, five cases with adnexal rupture, and one case of ectopic tubal pregnancy. Twenty-five cases were accidentally found during an ultrasound for GIT symptomatic problems, and most of them were of simple follicular cysts. Early puberty and postpubescent metrorrhagia were complications in juvenile granulosa cell tumors with annular tubules. The presented asthenia as the main symptom was associated with five cases of ovarian malignancy Table 1.

The serologically measured tumor markers results for the patients were as follows; an increase (AFP and β-HCG) suggested a malignant germ cell tumor (MGT) ($P < 0.00001$) with a sensitivity of 92.8%, a specificity of 87.5%, PPV of 81.2%, NPV of 95.4%, and accuracy of 89.4%. Levels of inhibin were measured in two patients with sex cord tumors; only one case of JGCT was positive. CA 125 serum level was elevated in the borderline/malignant epithelial tumors and one patient with JGCT Table 2.

One hundred and twenty patients were encountered in our study; one hundred and seven patients were defined to have ovarian lesions; eighty-eight lesions were single and unilateral, and eighteen were single bilateral lesions described as (ten PCO, one immature teratoma, one Mets, one endometrioma, and five dysgerminomas), and one was multiple bilateral presented as collision tumor (teratoma with dysgerminoma). On the other hand, we had thirteen patients identified with non-ovarian adnexal lesions; four cases had bilateral tubal pathologies, and the rest had unilateral lesions Table 3.

Different imaging modalities were entitled in our study; almost all patients had US examinations and always identified adnexal pathologies. Sufficient US imaging interpretation to reach the final diagnosis was performed in forty-one cases without any further imaging distributed among typical MCT, simple follicular cyst, PCO, corpus luteum cyst, ectopic tubal pregnancy, hemorrhagic cysts, ovarian endometriomas, and ectopic pelvic kidney with sensitivity and specificity of 100% each. The rest of the cases were in need of further imaging tools; the overall CT scans are performed in thirty cases, while MRI is done for seventy patients Table 3.

The distribution of different types of adnexal lesions is analyzed in comparison to the histopathological /surgical results in Table 4.

We analyzed the distribution of the different ovarian lesions to the age in the second and third decades in Notable non-tumoral pathologies are the upper hand in both decades, followed by benign tumors in the first

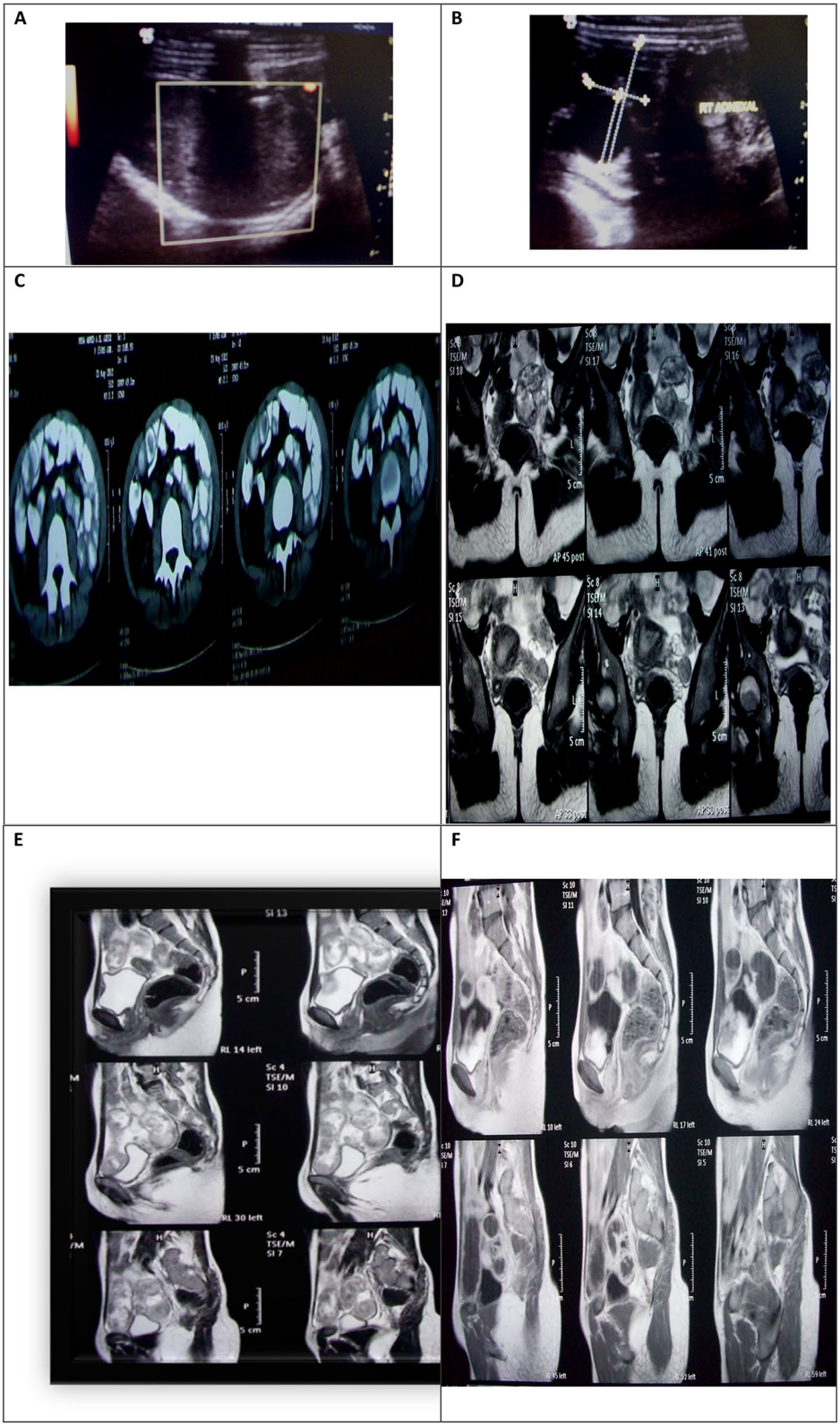


**Fig. 5** A 15-year-old female patient presented with abdominal pain (**A** and **B**). The US showed a tubular cystic adnexal structure. **C** CT abdomen showed terminal ileum intra-luminal polyp. **D** and **E** MRI coronal and sagittal cuts revealed bilateral tubular cystic lesions of heterogeneous signal intensities. **F** Post-contrast enhancement revealed peripheral avid contrast enhancement. This case underwent colonoscopy and biopsy from an ileal polyp and revealed caseating granuloma along with a high tuberculin level

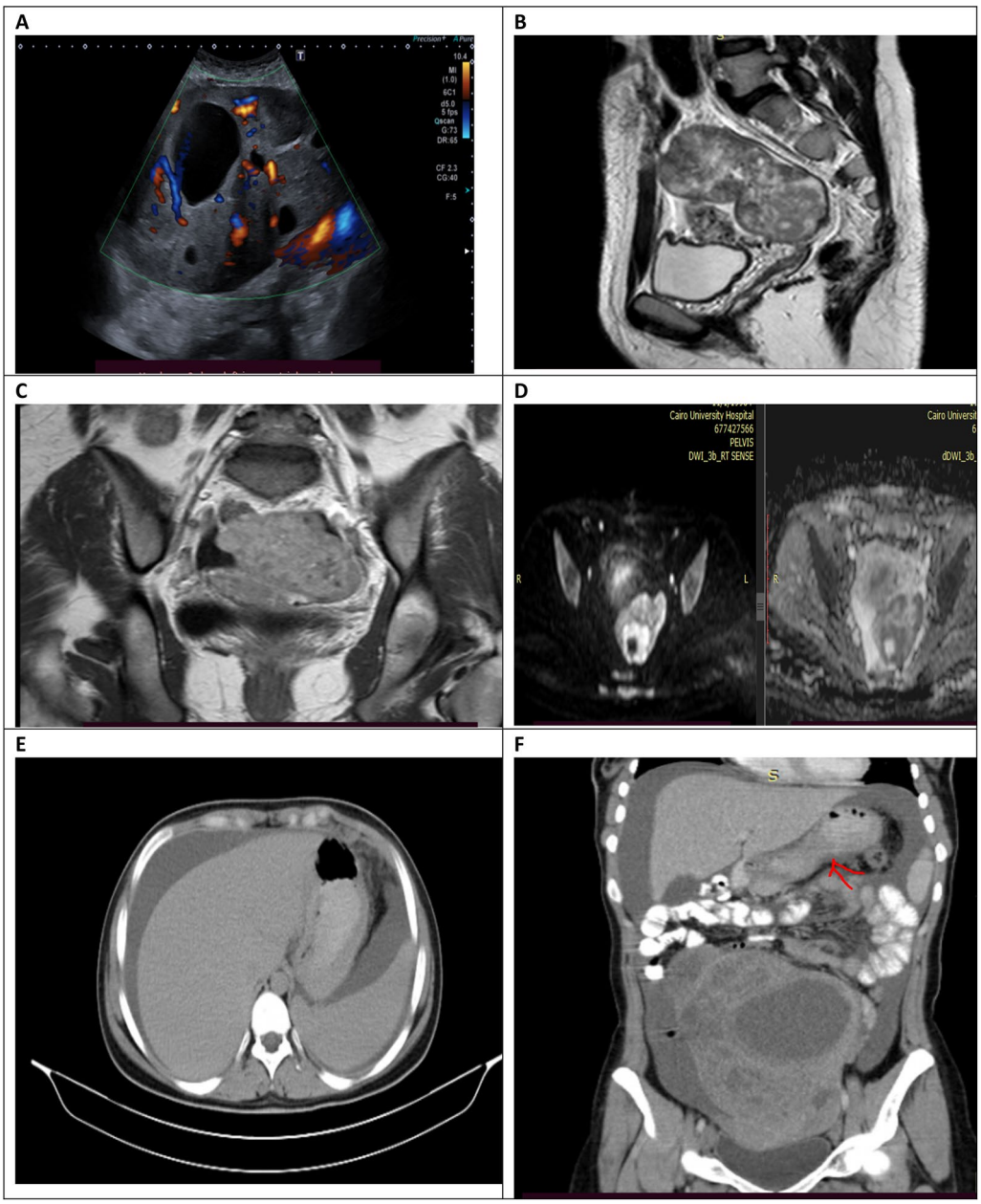


**Fig. 6** 23-year- old female presented with abdominal distension. **A**. on US ascites was seen with an enlarged left ovarian with spared follicles within. On MRI **B**. sagittal T2 showed predominantly solid left adnexal mass showing homogenous contrast enhancement (**C**), and restricted diffusion (**D**). On doing CT (**E** and **F**) axial and coronal cuts revealed thickening of the gastric wall is seen (red arrow). Biopsy from the stomach revealed gastric carcinoma with ovarian Krukenburg metastasis

decade, and the overall malignancy is common in the second decade except for germ type as shown in Fig. 1.

The mean size of borderline and malignant ovarian lesions was 10.9 cm (5–17), whereas the mean size of benign ovarian lesions was 8.3 cm (3–13.7). In situations with multiple/bilateral lesions, only the size of the largest lesion was considered. The threshold of 12 cm improved the ability to differentiate between benign and borderline/potentially malignant tumors ($P=0.04$). The distribution of the lesions' solid and cystic characteristics was highly indicative of malignancy ($P$ 0.001). Tumoral enhancement and/or vascularization on Doppler ultrasound were significantly associated with malignancy ($P<0.00001$). Only three malignant tumors including their ruptures had voluminous ascites in comparison to benign lesions, thus making it a strong predictive factor

**Table 1** Clinical presentation of the studied patient

| Number of patients, n (%) | 120 |
|---|---|
| Mean age in years ± SD | 15 ± 8.6 |
| Pubescent not having menarche | 40 |
| In menarche status: | 80 |
| Regular | 65 |
| Not regular | 15 |
| Revealing the main symptoms: | 120 |
| Abdominal pain | 35 |
| Palpable mass | 10 |
| Distended abdomen | 21 |
| Nausea/Vomiting | 10 |
| Fever | 10 |
| Asthenia | 5 |
| Early puberty | 2 |
| Postpubescent metrorrhagia | 2 |
| Chance discovery | 25 |
| Number of surgically managed patients | 56 |
| Number of patients under conservative management or follow up | 62 |

**Table 2** Tumor markers for cases of ovarian lesion

| Tumor markers measured | Abnormal (n = 28) | Associated pathology |
|---|---|---|
| AFP | 9 | Malignant germ cell tumors. Immature teratoma |
| β-HCG | 8 | Dysgerminoma, ectopic pregnancy, and embryonal carcinoma. Immature teratoma |
| LDH | 5 | Dysgerminoma |
| CA-125 | 6 | Borderline/malignant Epithelial tumors, JGCT |
| Inhibin | 1 | Granulosa cell tumor |

**Table 3** Distribution of the lesions with different modalities done for our studied cases

| Number of patients, n (%) | *N* = 120 (100%) |
|---|---|
| US performed, CT(n) | 10 |
| US, MRI | 50 |
| US, CT, MRI | 20 |
| US only | 40 |
| Origin of the lesion: | *N* = 120 |
| Ovarian only | 105 |
| Tubal | 4 |
| Appendicular | 2 |
| Krukenburg tumor | 1 |
| Lynch syndrome | 1 |
| Peritoneal | 2 |
| Others | 5 |
| Ovarian lesions: | *N* = 107 |
| Single, unilateral ovarian lesion (n) | 88 |
| Single, bilateral | 18 |
| Multiple, unilateral | 1 |
| Diameter of the scanned adnexal lesion mean ± SD | (3-15 cm) with a mean of 5.6 cm |

related to malignancy ($P = 0.03$). Intermediate/heterogeneous SI on T2WI of the solid components was more commonly observed in borderline/malignant lesions than benign masses with a *P*-value of 0.0001 Table 5.

DWI sequence had an important role in the benign and malignant discrimination of ovarian lesions as well as in the identification of the nature of the lesions in our study. Most of the solid components of the borderline/malignant tumors (*n*, 14/16) and only five cases of benign germ cell tumors (3 atypical MCT and 2 immature types) were restricted with a P value of 0.001. Facilitated diffusion was found in two masses of borderline tumors. Malignant ovarian lesions' mean ADC value was statistically substantially lower than benign ovarian lesions' mean ADC value. (0.89 ± 0.5 and 1.49 ± 0.6, respectively) Table 5.

For identification of the lesions' nature, in the group of non-tumoral ovarian lesions, restricted diffusion was also noted in twenty-six cases with intralesional blood components (10 hemorrhagic cysts, 10 endometriomas, and 6 torsed ovaries with surgically confirmed hemorrhagic infarcts) (Fig. 7). We also noticed significantly lower ADC values in endometriomas than in hemorrhagic cysts aiding in their differentiation and diagnosis. Also in extra-ovarian lesions, we had two cases showing restriction correlated to the inflammatory imaging findings on conventional MRI and diagnosed as pelvic infection.

Seven cases of MCT of the ovary in our study showed the typical US features of mural nodule protruding from a cystic lumen or diffusely/partially echogenic mass that represents sebaceous material, multiple thin echogenic bands attributable to hair, fat-fluid levels, floating debris, or a combination of these features. Acoustic shadowing of calcification was also detected. This was quite prescient of a mature teratoma by US diagnosis with specificity and sensitivity of 100% each in comparison to pathology with no need for further imaging tools.

Intralesional fat was only detected in the group of germ cell tumors by CT/MRI studies: two cases of complicated mature teratomas with torsion, one case of atypical MCT, one case of immature teratomas, and one case of MCT on top of dysgerminoma (collision tumor) with a sensitivity of 87.5%, specificity of 100%, PPV of 100%, NPV OF 96.7%, and accuracy of 97.3%. Also, we noticed that the intra-tumoral calcifications were seen in germ cell tumors; 75% and 28.5% of benign and malignant

**Table 4** Distribution of type of ovarian lesion according to histopathology

| Distribution of different ovarian lesions | Benign | (n) | Borderline | *N* | Malignant | *N* |
|---|---|---|---|---|---|---|
| Tumoral lesions: *N* = 38 | *N* = 22 | | *N* = 3 | | *N* = 11 | |
| Germ cell tumors | Mature teratomas | 10 | | | Dysgerminoma | 5 |
| | Immature teratoma | 2 | | | Yolk Sac Tumor | 1 |
| | | | | | Embryonal carcinoma | 1 |
| Stromal tumors | | | | | Juvenile granulosa cell tumor | 2 |
| Epithelial tumors | Mucinous cystadenomas | 7 | Mucinous cystadenofibromas | 3 | Cystadenocarcinoma | 2 |
| | Serous cystadenomas | 3 | | | | |
| *Others* | | | | | | |
| Gastric cancer with krukenburg | 1 | | | | | |
| Lynch syndrome: | 1 | | | | | |
| *Non-tumoral lesions* | *N* = 69 | | | | | |
| Follicular cyst | 20 | | | | | |
| Hemorrhagic cyst | 10 | | | | | |
| Corpus luteum cyst | 4 | | | | | |
| Endometriomas | 10 | | | | | |
| Adnexal torsion on ovarian mass | 3 | | | | | |
| Adnexal torsion on a normal ovary | 7 | | | | | |
| Adnexal rupture | 5 | | | | | |
| PCO | 10 | | | | | |

types respectively with a sensitivity of 57.8%, specificity of 100%, PPV of 100%, NPV of 70.3%, and accuracy of 87.9%.

In our study, the two cases of granulosa cell tumors showed abnormal endometrial thickening. One case of 14 years old was associated with postpubertal uterine pear-shaped as a contrast to the pre-pubertal tubular configuration. Lymph node extension was assessed and we noticed that four cases of malignant ovarian lesions (2 dysgerminomas, 1 Kruckenberg, 1 epithelial, 1 Lynch syndrome) were associated with retroperitoneal and para-aortic lymph nodes enlargement with restricted diffusion (Fig. 8).

In our study, we had one case of hereditary tumor syndrome (lynch syndrome; endometrial, ovarian, and colorectal cancers) which was linked to ovarian neoplasms. If a patient with one of these syndromes has imaging that shows a generic ovarian tumor, being aware of this connection might raise expectations of particular neoplasms. Additionally, early deployment of syndrome-specific surveillance, which would benefit patients and their families, is made possible by the early discovery of these syndromes in a patient who initially appears with a related malignancy (Fig. 9).

Complications of the ovarian lesions were detected in our study by the role of imaging and surgical results; spontaneous rupture and torsion with/out underlying mass. Our US/CT analysis strongly identified ruptured ovarian mass prior to surgery only in a case of hemorrhagic cyst accompanied by acute abdominal pain, voluminous ascites, and discontinuous lesion wall on imaging. On the other hand, seven out of ten cases associated with torsion were clearly diagnosed with the aid of US/CT and the clinical presentation of acute pelvic pain prior to surgery with a sensitivity and specificity of 70% and 100%, respectively.

We had a dilemma of adnexal non-ovarian lesions that made a struggle in their differentiation and diagnosis. With the help of CT/MRI, we could almost diagnose them by their imaging finding characteristics and clinical data. As being separate from the ipsilateral ovary, the tubal adnexal masses were suspected by their characteristic tubal, elongated-shaped bilateral lesion with incomplete septa. Two cases were associated with known TB patients, and two cases of hemtosalpyinx were accompanied by a vaginal septum and hematometra. Two cases of appendicular abscesses were suspected in case of acute abdominal pain on the right iliac fossa, with imaging characteristics of a collection of air and fecolith surrounded by inflamed non-compressible fatty tissue Table 6.

One case of ectopic tubal pregnancy has been encountered in our study. The diagnosis was established based on clinical symptoms of abdominal pain, irregular vaginal bleeding, the "discriminatory zone" for β-hCG is 1,500–2,000 mIU/mL for TVUS, and a positive pregnancy test, and no evidence of an intrauterine pregnancy exists. In this case, a characteristic tubal

**Table 5** Criteria for ovarian tumor characterization and their statistical analysis in our study

| Criteria | Benign *N* (22) | Borderline or malignant lesions *N* (16) | *P* value | Sensitivity (%) | Specificity (%) | PPV (%) | NPV (%) | Accuracy |
|---|---|---|---|---|---|---|---|---|
| Enhancement and/or vascularization on Doppler US | | | < 0.00001 | 87.5 | 90.9 | 87.5 | 90.9 | 89.4 |
| Yes | 02/22 | 14/16 | | | | | | |
| No | 20/22 | 02/16 | | | | | | |
| Predominantly solid | 02/22 | 10/16 | | 81.2 | 86.3 | 81.2 | 86.3 | 84.2 |
| Heterogeneous mixed cystic and solid | 01/22 | 03/16 | | | | | | |
| Predominantly cystic: | | | 0.001 | | | | | |
| -thickened septate, | 19/22 | 03/16 | | | | | | |
| papillary projection, mural nodules, vegetation | No | Yes | | | | | | |
| low T2 of the solid components | 02/22 | 02/16 | 0.3 | | | | | |
| Intermediate/heterogeneous T2 of the solid components | | | | 62.5 | 66.6 | 90.9 | 25 | 63 |
| Predominant low DWIs (not restricted) | 01/22 | 14/16 | 0.0001 | | | | | |
| Predominant high DWIs (restricted) | | | | | | | | |
| Data not available on MRI | | | | | | | | |
| Mean ADC value | | | | | | | | |
| | 10/22 | 02/16 | 1 | 87.5 | 66.6 | 73.6 | 83.3 | 77.4 |
| | 05/22 | 14/16 | | | | | | |
| | 07/22 | 0/16 | | | | | | |
| | 1.49 ± 0.6 | 0.89 ± 0.5 | < 0.0001 | | | | | |
| Voluminous ascites | 0/22 | 03/16 | 0.03 | 18.7 | 100 | 100 | 62.8 | 65.7 |
| Size of the lesion | | | 0.04 | 37.5 | 86.3 | 66.6 | 65.5 | 65.7 |
| ≥ 12 cm | 03/22 | 06/16 | | | | | | |
| < 12 cm | 19/22 | 10/16 | | | | | | |

ring sign and ring of fire signs were detected with the aid of transvaginal US.

## Discussion

Adnexal lesions in young females represent a very heterogeneous group of histopathological entities. The ovaries, fallopian tubes, and other pelvic organs can give rise to adnexal masses. Adnexal masses can be either malignancies or inflammatory or functional cysts The ability to distinguish between benign and malignant lesions is essential for choosing the best course of therapy. Identification of the exact area of the lesion's origin and differentiation from other disorders that appear with comparable symptoms is the first diagnostic step in young girls with a suspected adnexal lesion.

In our study, we noticed that 57.5% of our studied cases were non-tumoral ovarian lesions in origin. With an estimated prevalence of 45% of ovarian cystic lesions, physiological follicular and corpus luteal cysts account for 20% of the studied cases (their size reached not more than 7cm). This incidence percentage was very close to the literature by Schlattau [11] who said that ovarian cysts are a common discovery in women of reproductive age, with an estimated incidence of 18%.

In our study, 31% (nearly one-third) of the studied adnexal lesions were ovarian tumors and most of them were benign lesions with more distribution in the 2nd decade of life and malignant ovarian tumors account for 9.1% with high prevalence association with increasing age (3rd decade of life) except for germ cell type. These findings were near to a major study by Templeman et al [12] who mentioned approximately ovarian tumors account for one-third of adnexal masses. Children and adolescents with malignant ovarian tumors make up 4–9% of all cancer cases in this age group and are considered to increase with age. Also, Hassan et al [13] verified ovarian tumors are the most common tumors discovered in the female genital tract during the first two decades of life.

In our study, germ cell tumors represent 50% of our studied ovarian tumors and are distributed in 2nd decade

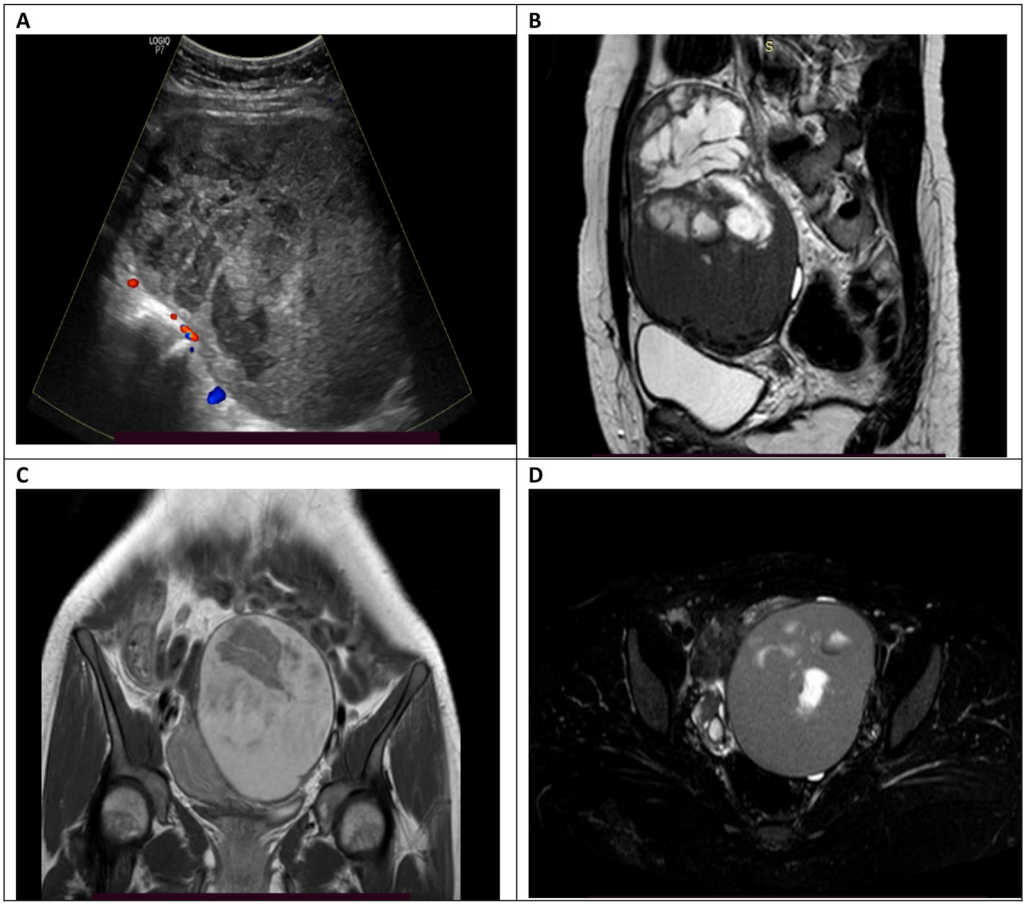


**Fig. 7** A 19-year-old female patient was presenting with pelvic pain, she had idiopathic thrombocytopenic purpura. **A.** US and Doppler revealed a large complex echogenic oval mass with cystic spaces devoid of vascularity on color Doppler. **B.** Sagittal T2 W MRI, **C.** coronal T1 post-contrast, **D.** T2 SPAIR: left adnexal complex cystic lesion measuring 13.5 × 10.8x8.2 cm in its maximum dimensions. It appears of heterogeneous signal with a hyperintense component in T1 and T1 fat suppression with mixed intermediate and bright T2 signal (shading effect), the hypo intense part showed no contrast enhancement. No evidence of soft tissue component. Findings those of hemorrhagic cyst, on follow-up decreased in size with a newly developed one at the right side

of life contrary to 3rd decade of life where most of the tumors were of epithelial and sex cord types. Also, most of the malignant tumors in these decades of life were dysgerminomas representing 45% of all detected ovarian cancers. These were in line with a study by Kiran Khedkar [14]. He stated that germ cell tumors make up two-thirds of pediatric malignant cancers, and dysgerminomas, which make up 30–40% of all malignant germ cell tumors, are the most common. When compared to adult ovarian tumors, which are 90% epithelial cell origin and 10% non-epithelial in origin,

We and Kiran Khedkar [14] agreed that the most frequent symptom was an abdominal ache representing 55% in our study, followed by a movable, palpable abdominal tumor. Also, we were in line with Pérouxa's [15] statement; the clinical image which could represent a surgical emergency was vomiting, nausea, and acute pain. In our study, those were associated with ovarian rupture, torsion, and pelvic infection representing %. Also, we detected that most of the adnexal torsions were not tumoral (7/10) and three cases (2.5%) were associated with teratomas. This was also matched with Oltmann SC [16] who reported 1.8% of ovarian torsion was revealing a malignant tumor.

Talma et al. [17] stated an evaluation of the girl's age and her hormonal level is crucial for the assessment of the underlying ovarian lesions as some endocrinal disorders (early puberty, postpubescent metrorrhagia, virilization) delineating underlying sex cord-stromal tumors. In our study, the two cases of JGCT presented with abnormal endocrinal symptoms as well accompanied by changes in their uterine endometrial thickness and shape.

In the setting of ovarian neoplasms, we were in agreement with Pérouxa [15] in that Tumor indicators are crucial for underlining the value of preoperative testing for diagnosis. Teratomas can only be identified by the

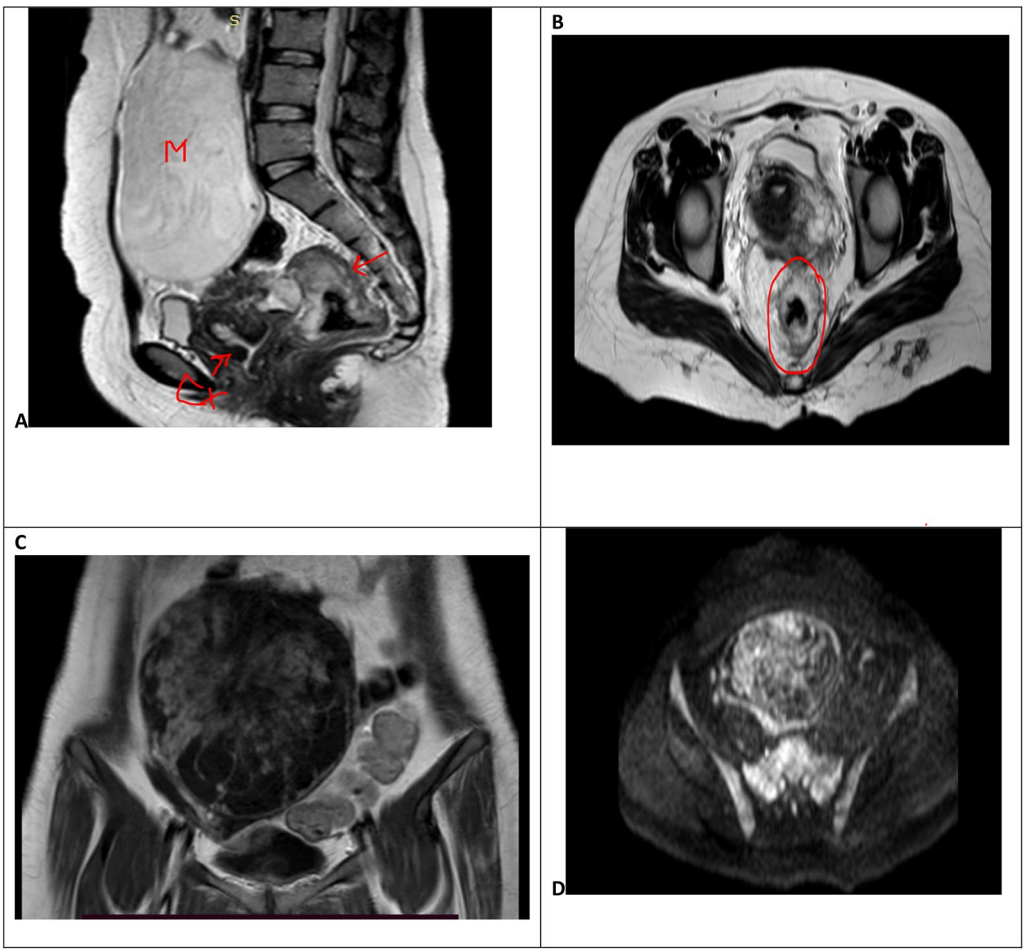


**Fig. 8** A 27-year-old female presenting by an adnexal complex cyst on the US (**A**), sagittal and axial T2 (**B**) showing irregular, incomplete, circumferential mural thickening of the rectum is noted, with eccentric lumen, enhancing on post-contrast and restricted on Diffusion (arrow and circle). **C** and **D**: showing left adnexal complex cystic lesion is noted. It is hypointense on T1 and hyperintense on T2 WIs, exhibiting mural and septal enhancement on the post-contrast study, with areas of a focal mural and septal thickening. Pathology revealed rectal carcinoma and left borderline mucinous tumor, coinciding with LYNCH syndrome

presence of AFP, a marker of a yolk sac component, and hCG, a sign of syncytial-trophoblast cells. These indicators tend to be more prevalent in young teratomas. Specific for sex cord (JGCT) tumors was Inhibin. CA 125 is not particular.

This study established that fat and calcifications are characteristic of germ cell tumors. (80% of mature teratomas and 50% of immature teratomas) (75%of mature teratomas and 28.5% of MGT), respectively. These findings are mostly near to Kiran Khedkar'sstudy [14] that found fat is 88% in mature teratomas and 100% in immature teratomas). Calcifications are 73% in mature teratomas and 67% of MGT.

Our study suggested various imaging diagnostic predictive criteria for malignant ovarian tumors which were of significant value in the discrimination between benignity and malignancy including tumor enhancement (or vascularization on Doppler ultrasound), the size of a tumor with a threshold of 12 cm, voluminous ascites, complex lesion or predominant solid with heterogeneous or intermediate T2 solid components, restricted DWI with low ADC values. Kiran Khedkar [14] also studied those factors and almost all of them were of significant value and we are in line with it. Another study by Eskander [18] stated malignant ovarian tumors were 17.3 7.1 cm in size compared to benign masses' 8.8 7.1 cm (P 0.001).

We and a review of literature by Lisa Agostinho [19] agreed and advised to use of DWI as a supplementary scan. Generally, malignant tumors typically exhibit restricted diffusion with low ADC values, but benign tumors do not. However, teratomas, endometriomas, hemorrhagic cysts, ovarian abscesses, ovarian infarction, and some benign sex cord-stromal tumors are among

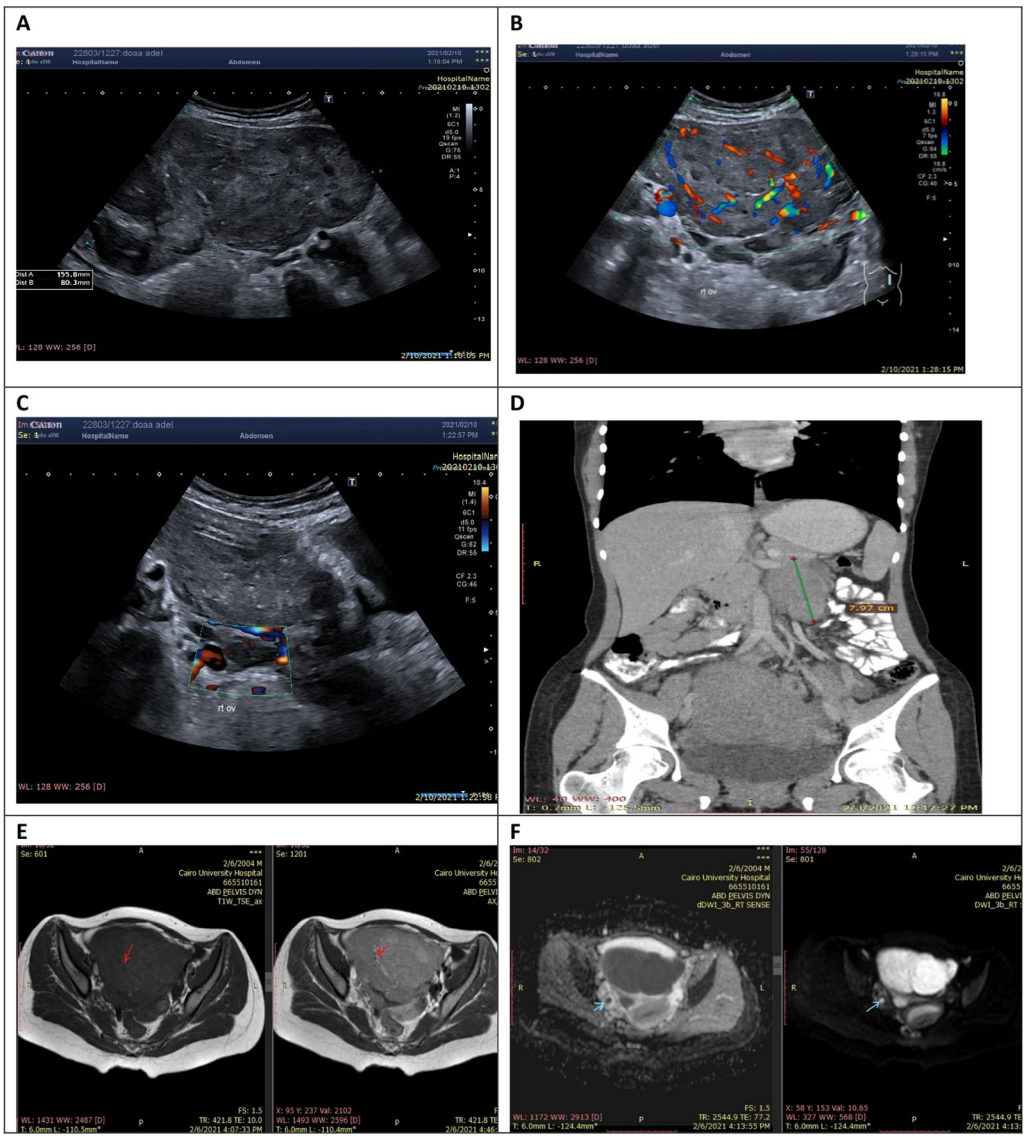


**Fig. 9** A 17-year-old female patient presented with abdominal distension (**A**). The US shows a solid lobulated mass left adnexal lesion. **B** and **C** color Doppler application showing central and peripheral vascularity and a small mass seen inside the follicle in the right ovary. **D** coronal CT showing solid enhancing mass with a large left para-aortic lymph node. **E** MRI images T1 and T1 post-contrast showing Typical enhancing septa. **F** Diffusion and ADC map showing restricted diffusion, note small restricted mass in the right ovary (blue arrow). Imaging suggestive of bilateral dysgerminoma stage 3 and the pathology confirmed the diagnosis of dysgerminoma

the exceptions to the rule that radiologists should be aware of. Despite the restriction property of those benign lesions, almost all of them have higher ADC values than that malignant lesions.

The ultrasonography examination in our cases was highly suggestive and conclusive of the diagnosis in 34.1% without further need for advanced imaging with a sensitivity and specificity of 100% besides it was considered an early detection screening method of ovarian tumors and helping in the discrimination between benignity and malignancy of the ovarian tumors with calculated overall sensitivity and specificity of 93.7 and 88%, respectively. MRI and DWI have raised the sensitivity and specificity up to 95.4 and 96.3% respectively in the setting of ovarian tumors nature discrimination. That was close to a study by Iyer VR [20], who concluded that contrast-enhanced MRI boosts sensitivity to 81% and specificity to 98% in the detection of ovarian cancer. Doppler ultrasonography offers an 84% sensitivity and an 82% specificity for cancer diagnosis.

**Table 6** Distribution of non-ovarian lesions according to histopathology

| Distribution of non-ovarian lesions | *N* = 13 |
|---|---|
| *Tubal* | *N* = 5 |
| Tuberculous salpingitis | 2 |
| Hematosalpinyx | 2 |
| Ectopic pregnancy | 1 |
| Appendicular abscess | 2 |
| *Peritoneal* | *N* = 2 |
| Parovarian cyst | 1 |
| Mesenteric cyst | 1 |
| *Others* | *N* = 4 |
| Endometrioma | 2 |
| Pelvic kidney | 2 |

## Conclusions

We concluded that the pediatric and adult populations had a wide range of adnexal lesions. In these young patients, maximizing survival while maintaining fertility takes priority. Diagnostic imaging tools had an upper hand in diagnosis, staging, and therapy plans. The preferred imaging technique for the initial assessment is still the US. CT and MRI are helpful supplemental tools for better lesions differentiation and characterization. The knowledge of typical and atypical imaging features of different ovarian lesions and their mimics in addition to clinical presentations as well as tumor marker profiles will lead to the appropriate diagnosis. The limitation of our study included a narrow range of extra-ovarian pathologies to be differentially diagnosed. Also, we had fair cases of different ovarian malignant tumors.

#### Abbreviations

ADC Apparent diffusion coefficient
AFP Alpha-fetoprotein
CA Carcinogenic antigen
CT Computed tomography
DWI Diffusion-weighted images
GCT Germ cell tumor
HCG Human chorionic gonadotropin
JGCT Juvenile germ cell tumor
LDH Lactate dehydrogenase
MCT Mature cystic teratoma
MRI Magnetic resonance imaging
PCO Polycystic ovaries
US Ultrasound

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#### Author contributions

SA is the guarantor of the integrity of the entire study. MH and BS contributed to the study concepts and design. TS, SA, and MH contributed to the literature research. BS and SA contributed to the clinical studies. All authors contributed to the experimental studies/data analysis. MH contributed to the statistical analysis. SA contributed to the manuscript preparation. SA and MH contributed to the manuscript editing. All authors have read and approved the final manuscript.

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#### Availability of data and materials

The corresponding author is responsible for sending the user data and materials upon request.

## Declarations

#### Ethics approval and consent to participate

The study was approved by the ethical committee of the Radiology Department of Kasr—Al-Ainy Hospital, Cairo University, which is an academic governmental supported highly specialized multidisciplinary Hospital. The included patients gave written informed consent.

#### Consent for publication

All patients included in this research were legible, and above 16 years of age. They gave written informed consent to publish the data contained within this study.

#### Competing interests

The authors declare that they have no competing interests.

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## Publisher's Note