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Original article

Role of Different Imaging Modalities in Assessment of Gynecological Causes of Acute Pelvic Pain

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Abstract:

Background: Acute pelvic pain refers to non-cyclic lower abdominal or pelvic pain lasting less than 3 months and is often associated with nausea, vomiting and / or leukocytosis. This study aimed to evaluate the role of different imaging modalities in the evaluation of gynecological causes of pelvic pain. **Methods:** This interventional study carried out on 73 female patients complaining of acute pelvic pain due to gynecological causes. All studied cases were subjected to clinical examination [Abdominal examination, pelvic examination, additional systemic examination]. Laboratory investigations [pregnancy testing [β-HCG], additional tests (CA125)]. Imaging modalities [Ultrasound (US), Computed Tomography (CT) or Magnetic Resonance Imaging (MRI). **Results:** Ultrasound results showed high positive prediction in most findings and high negative prediction value in all findings. There were high agreements in the following findings: Complicated uterine fibroid, Ectopic Pregnancy, Hemorrhagic Ectopic pregnancy, Hemorrhagic Ovarian Cyst, Tubo-Ovarian Abscess and Uterine Rupture. Moderate agreement shown in Endometriotic cysts. **Conclusion:** Ultrasound emerged as a primary imaging tool due to its non-invasiveness and cost-effectiveness, enabling the identification of various pathologies. CT and MRI provided additional insights in cases where ultrasound findings were inconclusive, facilitating detailed characterization of pelvic diseases.

Keywords: Imaging Modalities; Gynecological Causes; Acute Pelvic Pain; CT; MRI

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Introduction

Pelvic pain is a common complaint in female who present to emergency department. Although encountered frequently, the path to a definitive diagnosis is not always straight forward one, and imaging offers valuable tools to aid in this diagnostic challenge [(1)].

Acute pelvic pain refers to non-cyclic lower abdominal or pelvic pain lasting less than 3 months and is often associated with nausea, vomiting and / or leukocytosis [(2)].

The differential Diagnosis for abdominal pain is broad, encompassing gastrointestinal, gynecologic, urology, vascular and musculoskeletal conditions. An approach to narrowing the differential diagnosis based on the history, physical examination, laboratory testing and diagnostic imaging [(3)].

In females of reproductive age, the most common urgent causes of pelvic pain regarding the gynecological causes encountered are (ectopic pregnancy, endometriosis, ovarian torsion, pelvic inflammatory disease, ruptured ovarian cysts and tubo-ovarian abscess). Before ordering diagnostic imaging in premenopausal women, it is important to consider obtaining a (b- HCG) measurement to narrow the differential diagnosis and to limit the possibility of exposing an embryo or fetus to ionizing radiation. Transvaginal or transabdominal ultra sonography of the pelvis is the recommended imaging study for reproductive aged females in whom a gynecologic etiology is suspected or B-HCG test result is positive [(4)].

Ultrasound (transvaginal and trans abdominal) is the first-line imaging modality for initial evaluation of patients presenting with acute pelvic pain, with rather high sensitivity and specificity for detection of pathology. It is a low-cost diagnostic modality, widely available and lack of ionizing radiation [(5)]. Sometimes followed by computed tomography (CT) or MRI if US finding is equivocal, or if the abnormality extends beyond the field of view and characterization of pelvic diseases is required [(6)].

CT especially has high sensitivity and specificity in the setting of acute lower abdominal and pelvic pain. According to the American College of Radiology appropriateness criteria, a contrast-enhanced CT scan is the preferred imaging giving the high diagnostic performance, widespread availability and fast acquisition [(7)].

MR imaging is an excellent alternative to CT when considering absence of ionizing radiation and administration of contrast media. In addition, when US findings are non-diagnostic, MR imaging is an appropriate modality for lower abdominal and pelvic pain especially in young and pregnant patients [(8)].

The purpose of this study was to evaluate the role of different imaging modalities in the evaluation of gynecological causes of pelvic pain.

Patients and methods

This interventional study carried out on 73 female patients complaining of acute pelvic pain due to gynecological causes and referred to the Diagnostic Radiology Department of Benha University Hospital and El-Senbellawein General Hospital for evaluation during the period from 1st October 2022 to 30th September 2023.

An informed consent was obtained from patients. The study was approved by the Ethics Committee of research involving human subjects of Faculty of Medicine-Benha University.

Inclusion criteria were female [any age] with acute pelvic pain.

Exclusion criteria were non gynecological causes of pelvic pain.

All studied cases were subjected to the following: History Taking [Comprehensive patient history; presenting symptoms associated factors]. **Clinical examination** [Abdominal examination, pelvic examination, additional systemic examination]. **Laboratory investigations** [pregnancy testing [β-HCG], additional

tests (CA125)]. **Imaging modalities** [Ultrasound (US), Computed Tomography (CT) or Magnetic Resonance Imaging (MRI).

Imaging Modalities:

Employing a stepwise approach, initiating with ultrasound due to its accessibility, lack of radiation, and ability to provide preliminary findings. CT or MRI is employed when ultrasound findings are equivocal, when further characterization of abnormalities is needed, or when specific clinical scenarios (such as pregnancy) warrant alternative modalities [(9)].

Ultrasound (US): All patients underwent ultrasound as the initial imaging modality. Transabdominal and/or transvaginal ultrasound were employed based on clinical judgment and suspected pathology. US was performed to visualize pelvic organs, identify masses, assess for fluid collections, and detect abnormalities in real-time without exposing patients to ionizing radiation.

Computed Tomography (CT) or Magnetic Resonance Imaging (MRI): These modalities are utilized when ultrasound findings are inconclusive or when a more detailed characterization of pelvic pathology is necessary. CT Scan is particularly useful in acute settings due to its rapid acquisition, high resolution, and ability to visualize soft tissue and bony structures. MRI is preferred in cases where avoiding ionizing radiation and contrast media is crucial, especially in pregnant patients or when detailed soft tissue characterization is needed.

Follow-up: Patients received appropriate follow-up based on imaging findings and clinical outcomes to track response to treatment or disease progression.

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Statistical analysis

Statistical analysis was done by SPSS v26 (IBM Inc., Armonk, NY, USA). Quantitative variables were presented as mean and standard deviation (SD) and compared between the two groups utilizing unpaired Student's t- test and ANOVA (F) test. Qualitative variables were presented as frequency and percentage (%) and were analyzed utilizing the Chi-square test or Fisher's exact test when appropriate. The kappa statistics were calculated to estimate agreement between the methods. A two tailed P value < 0.05 was considered statistically significant.

Results

Table 1shows demographic data, distribution of radiological investigations and Acute pelvic pain diagnosis in the studied patients.

Table 2 shows distribution of types of radiological investigation according to diagnosis in the studied groups and association between diagnosis and Ultrasound findings in the studied cases.

Table 3 shows association between diagnosis and CT/MRI findings in the studied cases

The diagnosis of complicated uterine fibroid shows a significant difference between the age groups, with a statistically significant higher percentage observed in the >40 years old group compared to the <40 years old group (p=0.023). Furthermore, ovarian mass also exhibits a significant difference between the age groups, with a higher percentage in the >40 years old group and no cases observed in the <40 years old group (p=0.001). On the other hand, diagnoses such as ectopic pregnancy, endometriotic cysts, endometriosis, hemorrhagic ectopic pregnancy, ovarian cyst rupture, ovarian torsion, pelvic inflammatory disease, and tubo-ovarian abscess do not show significant differences between the age groups, P> 0.05. Tubo-Ovarian Abscess showed a significant difference between the BMI groups (p=0.018), with a higher percentage observed in the Obese group compared to the Average and Overweight groups. Although Ovarian Torsion did not reach statistical significance (p=0.07), there appears to be a higher percentage of cases in the Average BMI group compared to the other groups. Other diagnoses didn’t

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show significant difference between BMI groups. Table 4

A case of female patient 22years old. Presented to the emergency room by acute pelvic pain. She has a history of missed period, bleeding spots. Her pregnancy urine test was positive. She was referred to the radiology department for US examination. Figure 1

Table 1: Demographic data, distribution of radiological investigations and Acute pelvic pain diagnosis in the studied patients

		Total cases n=73
Age (years)		31.7±9.7
Age Groups	< 40 years old	63(86%)
	>40 years old	10(14%)
BMI (kg/m^2)		26.6±3.2
BMI Groups	Normal weight	23(32%)
	Overweight	39(54%)
	Obese	10(14%)
Radiological investigations		
Ultrasound or Vaginal Ultrasound	Pelvi-abdominal Ultrasound	58(80%)
	Vaginal Ultrasound	15(20%)
CT or MRI	CT	35(48%)
	MRI	38(52%)
Diagnosis	Hemorrhagic Ovarian Cyst	9(12%)
	Pelvic Inflammatory Disease	9(12%)
	Tubo-Ovarian Abscess	9(12%)
	Complicated uterine fibroid	6(8%)
	Ectopic Pregnancy	6(8%)
	Endometriosis	6(8%)
	ovarian mass	6(8%)
	Ovarian Cyst Rupture	6(8%)
	Ovarian Torsion	6(8%)
	Uterine Rupture	6(8%)
	Endometriotic cysts	3(4%)
	Hemorrhagic Ectopic pregnancy	3(4%)

BMI, Body mass index

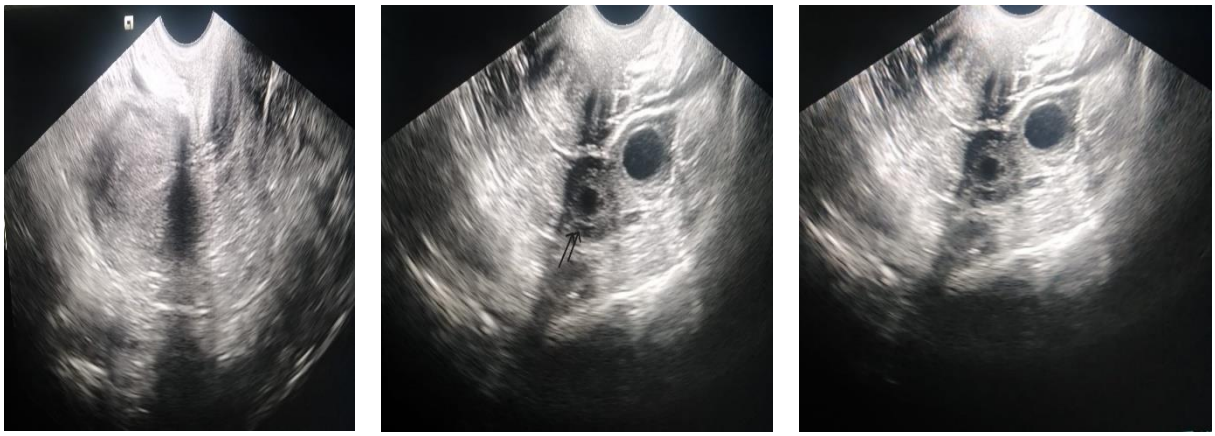

Figure 1: Un disturbed ectopic pregnancy

Table 2: Distribution of types of radiological investigation according to diagnosis in the studied groups and association between diagnosis and Ultrasound findings in the studied cases

	Pelvi-abdominal US n=58	**Vaginal US n=15**	**CT n=35**	**MRI n=38**
Complicated uterine fibroid	7(10%)	0(0%)	6(8.3%)	6(7.7%)
Ectopic Pregnancy	4(5%)	15(20%)	12(16.7%)	0(0%)
Endometriotic cysts	4(5%)	0(0%)	0(0%)	6(7.7%)
Endometriosis	4(5%)	15(20%)	6(8.3%)	6(7.7%)
Hemorrhagic Ectopic pregnancy	4(5%)	0(0%)	0(0%)	6(7.7%)
Hemorrhagic Ovarian Cyst	11(15%)	0(0%)	9(12.5%)	8(11.5%)
Ovarian mass	7(10%)	0(0%)	6(8.3%)	6(7.7%)
Ovarian Cyst Rupture	4(5%)	15(20%)	6(8.3%)	6(7.7%)
Ovarian Torsion	4(5%)	15(20%)	6(8.3%)	6(7.7%)
Pelvic Inflammatory Disease	7(10%)	15(20%)	6(8.3%)	11(15.4%)
Tubo-Ovarian Abscess	11(15%)	0(0%)	9(12.5%)	8(11.5%)
Uterine Rupture	7(10%)	0(0%)	6(8.3%)	6(7.7%)
	Pelvi-abdominal Ultrasound n=58		**Vaginal ultrasound n=15**	
Complicated uterine fibroid	Uterine fibroid		-	
Ectopic Pregnancy	free pelvic fluid		adnexal mass	
	Ectopic pregnancy		-	
Endometriotic cysts	Normal		-	
Endometriosis	Heterogeneous, hypoechoic masses (endometriomas)		ground glass appearance (endometriosis)	
Hemorrhagic Ectopic pregnancy	adnexal mass		-	
Hemorrhagic Ovarian Cyst	Cyst with reticular pattern, echogenic free fluid		-	
	Cystic lesion , echogenic free fluid		-	
Ovarian mass	irregular masses with ascites		-	
	Solid, irregular masses with papillary projections, ascites		-	
Ovarian Cyst Rupture	free pelvic fluid		Detailed cyst morphology, wall irregularities, free fluid	
Ovarian Torsion	Ovarian enlargement, absent color Doppler flow		Direct visualization of ovarian edema, stromal enlargement	
Pelvic Inflammatory Disease	Normal		Tubal thickening, fluid collections	
	Thickened endometrium		-	
Tubo-Ovarian Abscess	Complex adnexal mass with thick walls, internal debris		-	
Uterine Rupture	Discontinuity in uterine wall, free fluid, heterogeneity in the uterus		-	

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Table 3: Association between diagnosis and CT/MRI findings in the studied cases

	CT n=35	MRI n=38
Complicated uterine fibroid	Cystic hypodense appearance of fibroid mass	Complex high T2 signal intensity within a fibroid degeneration, Submucosal pedunculated fibroid may extend into endocervix
Ectopic Pregnancy	Heterogeneous adnexal mass, tubal ring sign	-
	Heterogeneous adnexal mass, tubal ring sign, pelvic hemoperitoneum	-
	-	Tl hypenntense cysts with T2 shading, fibrotic changes in pouch of Douglas
Endometriosis	Mass effect on pelvic structures, high-attenuation cysts (Endometriosis)	High T1 signal of endometriomas, fibrosis, and adhesions
	-	Heterogeneous adnexal mass, High signal on T1-weighted images, tubal thickening
Hemorrhagic Ovarian Cyst	Well-defined cystic lesion with high-attenuation contents with fluid level	cyst with high T1 signal (Hemorrhage), shading on T2 images
Ovarian mass	Solid, enhancing pelvic mass with possible peritoneal deposits	Ovarian malignancy with peritoneal and nodal spread
Ovarian Cyst Rupture	complex ovarian cyst with wall defect, Free fluid	Ovarian cyst rupture, cyst wall discontinuity, (Hemorrhage) hyperintense on T1
Ovarian Torsion	Enlarged ovary, whirlpool sign of twisted vascular pedicle	Ovarian enlargement, stromal edema, and hemorrhagic infarction
Pelvic Inflammatory Disease	thickened fallopian tubes, complex adnexal masses	bilateral thick-walled complex enhancing masses with tubal configuration and surrounding inflammation
	-	Tubal enhancement, thickened uterosacral ligaments, pelvic abscesses
Tubo-Ovarian Abscess	Complex fluid collection with enhancing rim, pelvic fat stranding	High-intensity fluid on T2-weight images, rim enhancement
Uterine Rupture	Discontinuity of uterine contour, hemoperitoneum, contrast extravasation	uterine wall disruption, high contrast resolution

Table 4: Distribution of diagnosis according to age groups and BMI

	< 40 years old n=63		**> 40 years old n=10**	**p**
Complicated uterine fibroid	3(4.7%)		3(28.6%)	0.023*
Ectopic Pregnancy	6(9.3%)		0(0%)	0.243
Endomctriotic cysts	1(2.3%)		1(14.3%)	0.887
Endometriosis	6(9.3%)		0(0%)	0.243
Hemorrhagic Ectopic pregnancy	3(4.7%)		0(0%)	0.497
Hemorrhagic Ovarian Cyst	9(14%)		0(0%)	0.098
Ovarian mass	0(0%)		6(57.1%)	0.001*
Ovarian Cyst Rupture	6(9.3%)		0(0%)	0.243
Ovarian Torsion	6(9.3%)		0(0%)	0.243
Pelvic Inflammatory Disease	9(14%)		0(0%)	0.098
Tubo-Ovarian Abscess	9(14%)		0(0%)	0.098
Uterine Rupture	6(9.3%)		0(0%)	0.243
	Average n=23	**Overweight** n=39	**Obese** n=10	**p**
Complicated uterine fibroid	0(0%)	4(11.1%)	1(14.3%)	0.263
Ectopic Pregnancy	3(12.5%)	3(7.4%)	0(0%)	0.716
Endometriotic cysts	1(6.3%)	1(3.7%)	0(0%)	0.942
Endometriosis	1(6.3%)	3(7.4%)	1(14.3%)	0.541
Hemorrhagic Ectopic pregnancy	0(0%)	3(7.4%)	0(0%)	0.389
Hemorrhagic Ovarian Cyst	4(18.8%)	4(11.1%)	0(0%)	0.585
Ovarian mass	0(0%)	4(11.1%)	1(14.3%)	0.263
Ovarian Cyst Rupture	3(12.5%)	3(7.4%)	0(0%)	0.716
Ovarian Torsion	6(25%)	0(0%)	0(0%)	0.07
Pelvic Inflammatory Disease	4(18.8%)	4(11.1%)	0(0%)	0.585
Tubo-Ovarian Abscess	0(0%)	4(11.1%)	4(42.9%)	0.018*
Uterine Rupture	0(0%)	4(11.1%)	1(14.3%)	0.263

* For significant p value (<0.05)

Discussion

According to demographic data of the patients studied, the mean age was 31.7 years with a standard deviation of 9.7 years. Most of the patients, comprising 86% of the sample, were below the age of 40, while the remaining 14% were aged 40 or above. In terms of body mass index (BMI), the mean value was 26.6 kg/m2 with a standard deviation of 3.2 kg/m2. The BMI groups revealed that 32% of the patients were classified as normal weight, 54% were classified as overweight, and 14% were classified as obese.

Comparable to our study, El-Gharib et al. included 49 patients with clinically enlarged uterus, pelvic mass with its nature and origin arc equivocal by trans-abdominal ultrasonography (TAS) and proved adnexal masses by US for further tissue characterization by MRI. Age of the studied patients ranged between 15 and 65 years with a mean age of 34.72 years [(10)].

According to radiological examination distribution in the studied patients, Pelvi-abdominal ultrasound was performed in 40 cases (80%), while vaginal ultrasound was conducted in 10 cases (20%). In terms of computed tomography (CT) or magnetic

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resonance imaging (MRI), CT scans were performed in 48% of the cases (24 cases), whereas MRI scans were conducted in 52% of the cases (26 cases).

In the case of acute abdominal pain, different studies have shown that US adds 40% more information than clinical examination alone and changes the management in 20% of cases [(11)]. Using US in patients with acute abdominal pain can decrease the number of emergency abdominal CT examinations by a half. The combined use of US and CT in patients with inconclusive US examinations in cases of acute abdominal pain will reduce the percentage of missed urgent diagnoses to 6% [(12)].

Based on the data provided on the diagnosis of acute pelvic pain in the studied groups, it can be observed that several conditions were identified. Hemorrhagic ovarian cysts, pelvic inflammatory disease, and tubo-ovarian abscess were each diagnosed in 12% of the cases (6 cases each). Complicated uterine fibroid, ectopic pregnancy, endometriosis, ovarian mass, ovarian cyst rupture, ovarian torsion, and uterine rupture were each diagnosed in 8% of the cases (4 cases each). Endometriotic cysts and hemorrhagic ectopic pregnancy were diagnosed in 4% of the cases (2 cases each).

Urgent conditions are the first etiologies to be considered and include ectopic pregnancy, ruptured ovarian cyst, ovarian torsion, appendicitis, and pelvic inflammatory disease (PID). PID, appendicitis, and ruptured ovarian cysts are the most common among these conditions [(13)].

Gaitán et al. compared the accuracy of laparoscopy performed within 24 h of admission and the conventional method based on clinical observation in the etiological diagnosis of non-specific acute lower abdominal pain (NSLAP) in women of reproductive age. A total of 110 patients met the selection criteria and were included in this study. The dominant cause of pain was PID (54% of all cases), followed by ovary tumors (15%) [(14)].

The present work presents the association between diagnoses and ultrasound findings in the studied cases. Pelvi-abdominal ultrasound was performed in 58 cases, while vaginal ultrasound was conducted in 15 cases. The study reveals specific ultrasound findings associated with each diagnosis. For instance, complicated uterine fibroid was associated with uterine fibroid on pelvi-abdominal ultrasound, while ectopic pregnancy was associated with free pelvic fluid and adnexal mass on vaginal ultrasound. Endometriosis was characterized by heterogeneous, hypoechoic masses (endometriomas) on pelvi-abdominal ultrasound and a ground glass appearance on vaginal ultrasound. Other diagnoses such as ovarian cyst rupture, ovarian torsion, pelvic inflammatory disease, and tubo-ovarian abscess also had distinct ultrasound findings associated with them.

The diagnosis of uterine fibroids is usually by ultrasound, either transabdominal or transvaginal. The typical appearance of a fibroid on ultrasound is that of a well-defined, hypoechoic mass arising from the myometrium. Acoustic shadowing may be present. Intramural involvement should be identified by ultrasound. In the case of fibroid degeneration, the mass may appear necrotic, with anechoic, irregular cystic spaces within. Saline instillation into the uterine cavity may help delineate fibroids on sonography. Uterine fibroids are a common incidental finding at laparotomy or laparoscopy and do not require intervention by the general surgeon [(15)].

Our study presents the association between diagnoses and CT/MRI findings in the studied cases. CT scans were performed in 35 cases, while MRI scans were conducted in 38 cases. The study reveals specific imaging findings associated with each diagnosis. For example, complicated uterine fibroid was characterized by a cystic hypodense appearance of the fibroid mass on CT scans and complex high T2

signal intensity within a fibroid, degeneration, and possible extension into the endocervix on MRI scans. Other diagnoses such as ectopic pregnancy, endometriosis, hemorrhagic ovarian cyst, ovarian mass, ovarian cyst rupture, ovarian torsion, pelvic inflammatory disease, tubo-ovarian abscess, and uterine rupture also had distinct CT/MRI findings associated with them.

MRI is the preferred imaging modality for characterizing uterine fibroids and identifying their exact anatomical location, though initial identification is usually by USG. Often, fibroids may also be found incidentally on plain radiographs or CT scans done for other indications [(16)].

According to the association between diagnosis and age distribution, the diagnosis of complicated uterine fibroid shows a significant difference between the age groups, with a higher percentage observed in the >40 years old group (28.6%) compared to the <40 years old group (4.7%). This difference is statistically significant (p=0.023). Furthermore, ovarian mass also exhibits a significant difference between the age groups, with a higher percentage in the >40 years old group (57.1%) and no cases observed in the <40 years old group (p=0.001). On the other hand, diagnoses such as ectopic pregnancy, endometriotic cysts, endometriosis, hemorrhagic ectopic pregnancy, ovarian cyst rupture, ovarian torsion, pelvic inflammatory disease, and tubo-ovarian abscess do not show significant differences between the age groups, as their p-values are greater than the conventional threshold of 0.05.

Zimmermann et al. conducted interviewing 21,479 women across 8 countries to gain patient-based prevalence data on uterine pain and bleeding indications and investigate uterine symptoms and women's treatment experiences. It was observed that with a mean age of 40.4 ± 6.9 years women who reported a diagnosis of uterine fibroids (n = 1,533) were in average 8 years older than women without the diagnosis (mean age 32.4 ± 9.6 years; n = 20,213; p < 0.001) [(17)].

According to association between diagnosis and BMI distribution, tubo-Ovarian Abscess showed a significant difference between the BMI groups (p=0.018), with a higher percentage observed in the Obese group (42.9%) compared to the Average (0%) and Overweight (11.1%) groups. Although Ovarian Torsion did not reach statistical significance (p=0.07), there appears to be a higher percentage of cases in the Average BMI group (25%) compared to the other groups. Other diagnoses didn't show significant difference between BMI groups.

Consistent with our findings, Ashrafian et al. included 72 patients met inclusion criteria. Thirty-eight patients had BMI > 30 and 34 patients had a BMI < 30. Their study reported that women with a BMI > 30 had a higher incidence of TOA (65.8% v. 38.2%) [(18)].

Ultrasonography results compared to CT/MRI in each finding as true positive, false positive, true negative and false negative to calculate positive predictive and negative predictive values for each finding of ultrasound result. Ultrasound results showed high positive predictions in most findings and high negative prediction value in all finding.

Similarly, Rostamzadeh et al. enrolled 323 women with acute pelvic pain with highly suspected ovarian torsion signs and symptoms. The sensitivity and specificity of sonography were 72.1% and 99.6%, respectively. Sonography had a positive predictive value of 96.9%, a negative predictive value of 95.9%, and a total accuracy of 96.0% for detection of ovarian torsion [(19)].

According to agreement analysis between ultrasound and CT/MRI results, there were high agreement in the following findings: Complicated uterine fibroid, Ectopic Pregnancy, Hemorrhagic Ectopic pregnancy, Hemorrhagic Ovarian Cyst, Tubo-Ovarian Abscess and Uterine

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Rupture. Moderate agreement shown in Endometriotic cysts. Low agreements were found in the following findings: Endometriosis, ovarian mass, Ovarian Cyst Rupture, Ovarian Torsion and Pelvic Inflammatory Disease.

MRI is usually reserved when the diagnosis of PID is not conclusive or if there is any suspicion of fistula, torsion, or tumor. MRI has a sensitivity, specificity, and diagnostic accuracy of 95%, 89%, and 93% in diagnosing the PID [20].

Conclusion

The study findings show the pivotal role of diverse imaging modalities in diagnosing gynecological causes of acute pelvic pain. Ultrasound emerged as a primary imaging tool due to its non-invasiveness and cost-effectiveness, enabling the identification of various pathologies. CT and MRI provided additional insights in cases where ultrasound findings were inconclusive, facilitating detailed characterization of pelvic diseases. The correlation between imaging findings and diagnoses highlighted significant associations for specific conditions, particularly in age and BMI distributions.

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Author contribution

Authors contributed equally in the study.

Conflicts of interest

No conflicts of interest

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