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Original Research Article

Spectrum of Gynecological Diseases on Magnetic Resonance Imaging with Ultrasound and Pathohistological Correlation

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Abstract

Background- Large numbers of females are affected by gynecological diseases. For early treatment, it is essential that there is accurate diagnosis about the type and extension of the lesions. Our primary aim was to determine the accuracy of magnetic resonance imaging (MRI) in the diagnosis of gynecological pathologies as compared to ultrasound (US).

Methods- This retrospective study included 166 females (>12 years of age) with gynecological diseases who underwent MRI in our department with ultrasound correlation (either transabdominal or transvaginal ultrasound imaging). Imaging findings of all patients who underwent surgery or biopsy were further correlated with pathohistology (which was considered as gold standard). We considered MRI as reference standard for all the patients who were not operated.

Results- In this study, the most common gynecological disease was ovarian neoplasms (37, 22.3%) followed by cervical carcinoma (26, 15.7%) and uterine fibroids (25, 15.1%). The overall sensitivity of US was 80.6% and MRI was 95% for precise diagnosis of all the lesions. Kappa statistics showed there was substantial agreement of US and almost perfect agreement of MRI with pathohistological findings in this study.

Conclusion- Imaging in gynecological diseases is indispensable for proper diagnosis, treatment and follow-up. Ultrasound is preferred as the primary modality for patients though it is operator dependent. MRI has higher sensitivity and accuracy and recommended for those lesions which are undecided on ultrasound.

Keywords: Gynecological pathologies, ultrasound, magnetic resonance imaging, pelvic imaging.

1. INTRODUCTION

Large numbers of females are affected by gynecological diseases. For early treatment, it is essential that there is accurate diagnosis about the type and extension of the lesions. These lesions present with similar complaints like lower abdominal pain, abnormal vaginal bleeding, swelling etc. The most commonly utilized non-invasive diagnostic modalities to assess the lesion type are ultrasound (US), magnetic resonance imaging (MRI) and computed tomography (CT)[(1,2)].

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The advantages of US over MRI are that US is low-priced, simply available, real-time, lack of radiation exposure[1,2], and well-accepted by patients along with visualization of internal vascularity on color Doppler study[3]. Hence, US has become the modality of choice for screening of high-risk women[4] and interval follow-up of benign lesions. Both transabdominal and transvaginal US imaging can be used for imaging[5]. Transvaginal scan imparts better resolution as the transducer frequency is higher[6] but are not done in unmarried females and those with large cervical mass[7].

MRI provides higher soft tissue resolution and contrast enabling better depiction of uterine and cervical zonal anatomy, intralesional solid and cystic components, extension of lesion, differentiation of intralesional hemorrhage/ fat/ calcifications, congenital anomalies of Mullerian duct, locoregional and distant lymphadenopathies and discrimination of benign and malignant adnexal masses[1,6]. It has currently been acknowledged as the imaging modality of choice for malignant gynecological diseases which entail more comprehensive evaluation, improved localization, more accurate staging, preoperative planning and post-treatment follow-up[2,7]. MRI, however, has limitations of more scanning time, more costly, limited accessibility, contraindicated in patients with pacemakers, metallic implants etc and arduous for females with claustrophobia[2].

CT is helpful for assessment of calcifications, fat, contrast enhancement of solid and cystic components[5], local extension and distant metastasis[2,7]. PET-CT has been found to be better in detecting remote metastasis[7]. There have been previous studies which have studied the utility of these imaging modalities individually and in combination. In our study, we aimed to evaluate the spectrum of gynecological diseases on pelvic MRI in a tertiary care centre in our population and correlate with ultrasound and pathohistology findings.

2. MATERIALS AND METHODS

We conducted a retrospective observational study in the radiology department in a tertiary care hospital for a period of 2 years 7 months. All female patients (>12 years of age) with gynecological diseases who underwent MRI in our department were included in this study. Ultrasound correlation was done for all patients with either transabdominal or transvaginal ultrasound imaging. Imaging findings of all patients who underwent surgery or biopsy were further correlated with pathohistology. We excluded patients if they had undergone incomplete imaging, had considerable artifacts in MRI images, previously received surgical/ chemotherapy/ radiotherapy treatment or had normal pelvic imaging findings. Consent was taken from all patients prior to imaging in the department. Ultrasound (US) imaging was carried out using GE LOGIQ machine with convex transducer (3 to 5 MHz) for transabdominal scan and endocavity micro convex transducer (8-10 MHz) for transvaginal scan under optimized adjustments.

MRI pelvis was done in a 1.5 Tesla scanner (Ingenia, Philips Healthcare) using dStream torso coil with 32 channels in supine position. Routine MRI protocol used in our department included the following sequences: T2-weighted sagittal (T2W SAG), axial (T2W AX) and coronal (T2W COR) sequences, T1-weighted axial (T1W AX) and coronal (T1W COR) sequences, T2-weighted Spectral Adiabatic Inversion Recovery axial (T2W-SPAIR AX) and sagittal (T2W-SPAIR SAG) sequences (for fat suppression), T2-weighted Short tau inversion recovery coronal (T2W-STIR COR) sequence, diffusion-weighted imaging (DWI) and T2*Gradient echo (T2*GRE) imaging. Contrast-enhanced T1-weighted Spectral

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Presaturation with Inversion Recovery axial (CE T1W-SPIR AX), coronal (CE T1W-SPIR COR) and sagittal (CE T1W-SPIR SAG) sequences were done after administration of contrast medium (using gadolinium-based contrast agents at bolus dose of 0.1mmol/kg with maximum of 20 ml).

The parameters for all these sequences are mentioned in the following order: TR (Repetition time) in milliseconds, TE (Time to echo) in milliseconds, ST (slice thickness) in mm, SG (interslice gap) in mm, FOV (field-of-view) in mm, MATRIX, NSA (number of signal averages) and flip angle (FA). The routinely used parameters for these sequences are: T2W SAG- TR 3000-4000, TE 80-90, ST 4-4.5, SG 0.6, FOV 220-300, MATRIX 275x260, NSA 2, FA 90^0; T2W AX- TR 3000-4000, TE 80-90, ST 4-5, SG 0.6, FOV 220-320, MATRIX 300x290, NSA 1, FA 90^0; T2W COR- TR 2800-3500, TE 80-90, ST 4-5, SG 0.5, FOV 220-320, MATRIX 320x290, NSA 2, FA 90^0; T1W AX- TR 500-600, TE 8, ST 4, SG 1, FOV 220-250, MATRIX 300x300, NSA 1.1, FA 90^0; T1W COR- TR 500-600, TE 10, ST 4.1, SG 0.5-0.8, FOV 250, MATRIX 275x250, NSA 1.3, FA 90^0; T2W-SPAIR AX- TR 4000-5000, TE 75, ST 4, SG 1.3, FOV 220, MATRIX 250x220, NSA 1.5, FA 90^0; T2W-SPAIR SAG- TR 4000-5000, TE 75, ST 4.5, SG 0.6, FOV 220, MATRIX 250x220, NSA 2, FA 90^0; T2W-STIR COR (with inversion time 150 ms)- TR 4500-5000, TE 75, ST 4.5, SG 0.5, FOV 240, MATRIX 220x200, NSA 1, FA 90^0; DWI (b values 0, 100, 800 with ADC maps)- TR 4000-5000, TE 85, ST 4, SG 1, FOV 300, MATRIX 500x500, NSA 1, FA 90^0; T2*GRE- TR 1500, TE 4.6, ST 4, SG 1.3, FOV 220, MATRIX 170x120, NSA 1, FA 45^0; CE T1W-SPIR AX/COR/SAG- TR 520-560, TE 7-8, ST 4, SG 0.6, FOV 250-300, MATRIX 300x275, NSA 1, FA 90^0.

All subjects with uterine diseases were assessed for uterine size, endometrial thickness, endometrial cavity, uterine contour, myometrial lesions, number of lesions, signal intensity/ echogenicity, junctional zone thickness, extent, involvement of adjacent organs on both MRI and US; also for vascularity on US and contrast enhancement on MRI. All subjects with ovarian/adnexal lesions and other gynecological diseases were evaluated for number, size, location, origin, extent, cystic and solid components, intra-lesional hemorrhage/ fat/ calcifications, septations/ mural nodules/ wall thickening of cystic lesions on MRI and US; also for internal vascularity on US and contrast enhancement on MRI. All the lesions were evaluated for extension into adjacent pelvic structures, lymphadenopathy, hydronephrosis, ascites, peritoneal deposits and screening of upper abdomen. All the lesions on US and MRI were tabulated and categorized into uterine, cervical and vaginal lesions as group 1 and ovarian, broad ligament, tubal/ tubo-ovarian and adnexal lesions as group 2. We correlated the MRI and US findings with final pathohistological diagnosis (which was considered as gold standard) for all the patients in whom it was available. We considered MRI as reference standard for all the patients who were not operated.

We used MedCalc software for statistical analysis of data. We ascertained mean with standard deviation (SD) and range for age. Frequency and percentage were determined for symptoms, age group distribution and gynecological diseases. Diagnostic precision of MRI and US was assessed with sensitivity, specificity, accuracy, positive and negative likelihood ratios and agreement with Kappa statistics.

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3. RESULTS

In this study, 166 patients with gynecological diseases on imaging were included with mean age of 39.9+/-15.4 years (range 14 to 80 years). The most common age group was 21-40 years (69, 41.6%) followed by 41-60 years (66, 39.8%), </=20 years (19, 11.4%) and 61-80 years (12, 7.2%). The mean age for benign lesions was 34.3+/-13.9 years and mean age of neoplastic lesions was 47.1+/-14.4 years. Most of the study patients presented with pain in lower abdomen/ pelvis (114, 68.7%) followed by abnormal vaginal bleeding (43, 25.9%) and menstrual abnormalities (36, 21.7%). More than one lesion was seen in 23 patients.

The gynecological diseases were classified into two groups- group 1) uterine, cervical and vaginal pathologies which included uterine fibroid (Fig. 1), adenomyosis, cervical carcinoma (Fig. 2), other malignant masses (including 8 cases of endometrial carcinoma (Fig. 3), 1 case of low-grade stromal sarcoma, 1 case of choriocarcinoma, 1 case of stump carcinoma, 2 cases of vaginal/vulva carcinoma), congenital mullerian duct anomalies (including uterine hypoplasia, absent uterus, bicornuate bicollis uterus, Robert's uterus, uterus didelphys), placenta accreta spectrum, uterine prolapse, vesicovaginal and rectovaginal fistula, scar dehiscence, endometrial collection and scar pregnancy; group 2) adnexal, ovarian and tubal pathologies which included ovarian neoplasms (Fig. 4), endometriosis, simple and hemorrhagic ovarian cysts, pelvic inflammatory disease (PID) and its complications (including tubo-ovarian abscess, hydrosalphinx, pyosalphinx), dermoid cyst, peritoneal inclusion cyst, broad ligament fibroid, twisted ovarian cyst and theca lutein cyst (Table 1).

Among the group 1, there were 59 (60.2%) benign lesions (most common was uterine fibroid) and 39 (39.8%) malignant tumors (of which cervical carcinoma was most common). Among the group 2, there were 61 (62.2%) benign lesions (most common was pelvic inflammatory disease) and 37 (37.8%) were neoplastic (of which epithelial ovarian tumors were most common). The most common gynecological disease in this study was ovarian neoplasms (37, 22.3%) followed by cervical carcinoma (26, 15.7%) and uterine fibroids (25, 15.1%).

The overall sensitivity of US was 80.6% and MRI was 95% for diagnosis of these lesions in this study. The sensitivity of US for benign lesions of group 1 was 74.6% and MRI was 98.3% for diagnosis in this study. With US, 44 cases out of 59 cases of benign lesions in group 1 were diagnosed accurately. Only 3 out of 7 cases of adenomyosis were diagnosed precisely, the remaining cases were either diagnosed as fibroid or suspicious of adenomyosis with bulky uterus. US was not confirmatory for 2 cases of vaginal fistula and 1 case of Robert's uterus (a rare type of congenital mullerian duct anomaly with a thick asymmetrical uterine septum, obstruction of endometrial cavity of hemiuterus and haematometra). 6 cases of small intramural uterine fibroids (less than 15mm) and 2 cases of subserosal fibroid were not accurately detected on US. MRI was able to accurately diagnose all benign lesions of group 1 except 1 case of large subserosal uterine fibroid with degeneration which was interpreted as ovarian neoplastic mass. More than one fibroid was seen in 11 patients.

The sensitivity of US for malignant lesions of group 1 was 76.9% and MRI was 92.3% for diagnosis in this study. On MRI, 1 case of low-grade uterine stromal sarcoma, 1 case of endometrial carcinoma (appearing as endometrial thickening without invasion) and 1 case of cervical carcinoma (appearing as bulky cervix) were misdiagnosed due to early stage of malignancy. However with US, 9 malignant cases of group 1 were not accurately diagnosed.

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The sensitivity of US for benign lesions of group 2 was 90.2% and MRI was 92.6% for diagnosis in this study. Out of 61 benign cases of group 2, 55 cases were accurately diagnosed on US including 12 cases of pelvic inflammatory disease and its complications, 2 cases of broad ligament fibroid, and 41 cases of benign ovarian cystic lesions. Out of 27 cases with pathohistological diagnosis among benign diseases of group 2, we had precise diagnosis in 25 cases on MRI. The sensitivity of US for neoplastic lesions of group 2 was 78.4% and MRI was 94.6% for diagnosis in this study. Out of 37 neoplastic cases of group 2, 29 cases were accurately interpreted on US and 35 cases on MRI.

Sensitivity, specificity and accuracy were higher with larger positive likelihood ratio and smaller negative likelihood ratio for MRI as compared to US in diagnosis of these diseases in our study. Kappa statistics showed there was substantial agreement of US and almost perfect agreement of MRI with pathohistological diagnosis in our study (Tables 2 and 3).

Table 1: Spectrum of gynecological diseases in the study group.

Group 1-Uterine/cervical/ vaginal lesions	No.	Group 2-Adnexal/ ovarian/tubal lesions	No.
Cervical carcinoma	26	Ovarian neoplastic mass	37
Uterine fibroid	25	PID and complications	15
Other neoplasms	13	Endometriosis	13
Placenta accreta spectrum	10	Simple ovarian cyst	11
Mullerian anomalies	9	Hemorrhagic cyst	11
Adenomyosis	7	Dermoid cyst	5
Fistula	3	Broad ligament fibroid	2
Uterine prolapse	2	Peritoneal inclusion cyst	2
Scar pregnancy	1	Theca lutein cyst	1
Scar dehiscence	1	Twisted ovarian cyst	1
Endometrial collection	1	Total	98
Total	98		

Table 2: Diagnostic precision of Ultrasound in gynecological diseases

Lesions	Sensitivity	Specificity	Accuracy	PLR	NLR	*k*
1.Uterine/Cervical/ Vaginal diseases in US						
1A. Benign lesions	74.6%	92.3%	81.6%	9.68	0.27	0.63
1B. Malignant lesions	76.9%	91.5%	85.7%	9.04	0.25	0.69
2. Ovarian/ Adnexal/ Tubal diseases in US						
2A. Benign lesions	90.2%	89.2%	89.8%	8.35	0.11	0.78
2B. Malignant lesions	78.4%	93.4%	87.8%	11.87	0.23	0.73

US- ultrasound, PLR-positive likelihood ratio, NLR- negative likelihood ratio, k- Kappa's statistics.

Table 3: Diagnostic precision of MRI in gynecological diseases

Lesions	Sensitivity	Specificity	Accuracy	PLR	NLR	*k*
1.Uterine/Cervical/ Vaginal diseases in MRI						
1A. Benign lesions	98.3%	97.4%	97.9%	37.81	0.017	0.95

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1B. Malignant lesions	92.3%	94.9%	93.9%	18.09	0.08	0.87
2. Ovarian/ Adnexal/ Tubal diseases in MRI						
2A. Benign lesions	92.6%	98.6%	96.9%	66.14	0.075	0.92
2B. Malignant lesions	94.6%	96.7%	95.9%	28.66	0.055	0.91

MRI- Magnetic resonance imaging, PLR-positive likelihood ratio, NLR- negative likelihood ratio, k- Kappa's statistics.

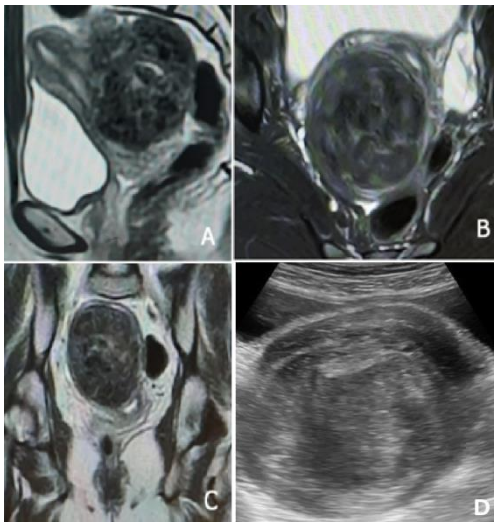

Fig.1. Subserosal fibroid: MRI-A) sagittal T2W, B) axial T2W fat-suppressed, C) coronal T2W; (D) Ultrasound.

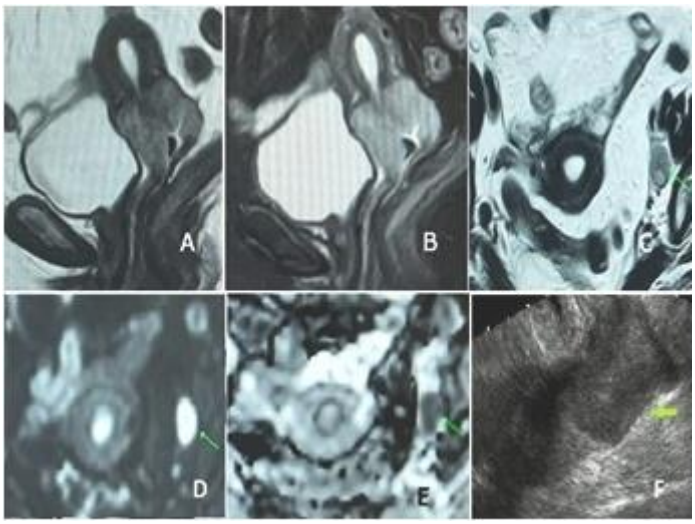

Fig.2. Cervical carcinoma: MRI-A) sagittal T2W, B) sagittal T2W fat-suppressed, C) axial T2W, D) axial DWI, E) ADC map; (F) Ultrasound. An enlarged metastatic left iliac lymph node on axial T2W showing restricted diffusion with low ADC value (arrow in C, D and E).

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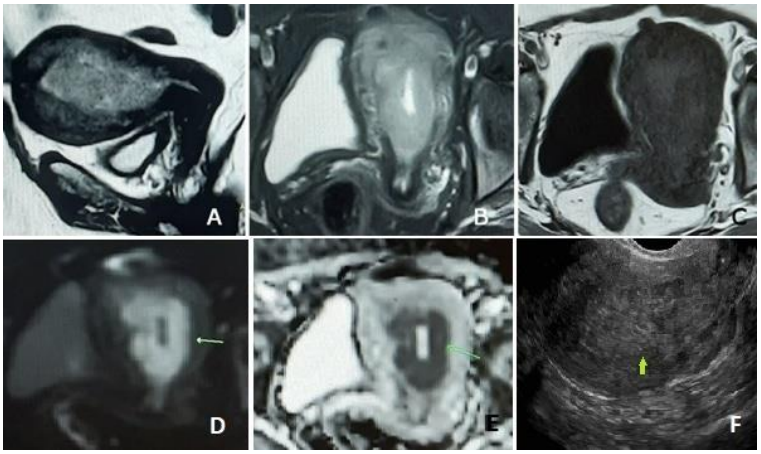

Fig.3. Endometrial carcinoma: MRI-A) sagittal T2W, B) axial T2W fat-suppressed, C) axial T1W, D) axial DWI, E) ADC map; (F) Ultrasound.

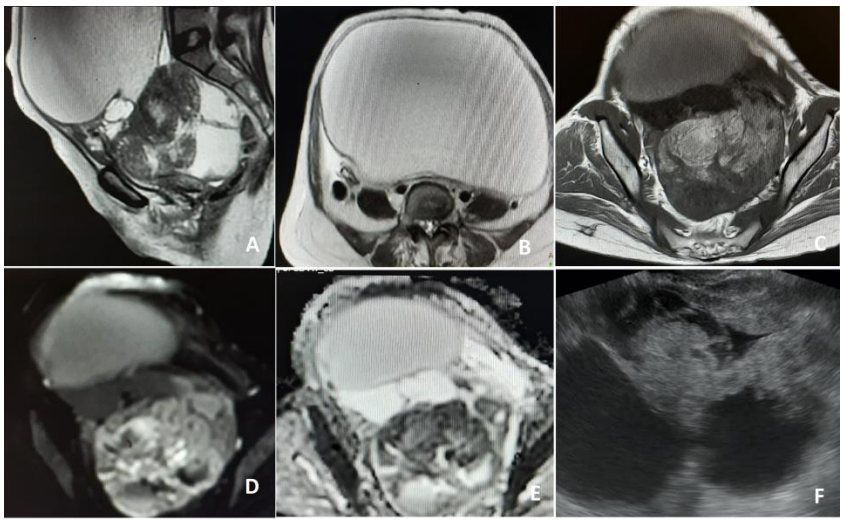

Fig.4. Ovarian mucinous cystadenocarcinoma: MRI-A) sagittal T2W, B) axial T2W C) axial T1W D) axial DWI, E) ADC map; (F) Ultrasound.

4. DISCUSSION

In this study, we evaluated diagnostic precision of MRI and US in both benign and malignant diseases of female reproductive system. Most of the patients (41.6%) were young adults (21-40 years) with gynecological diseases and lower abdominal/ pelvic pain was the most frequent presenting symptom (68.7%). We classified the gynecological diseases into two groups- group 1 included uterine, cervical and vaginal pathologies and group 2 had adnexal, ovarian and tubal pathologies, which were further sub-grouped as benign and neoplastic lesions.

The most common benign and neoplastic lesion in group 1 was uterine fibroid and cervical carcinoma, respectively. We found that for benign lesions of group 1, the sensitivity, specificity and accuracy were higher for MRI (98.3%, 97.4% and 97.9% respectively) as compared to US (74.6%, 92.3% and 81.6% respectively). Uterine fibroid is reported to be the commonest benign tumor in females[(8)], also found in our study group. Previous studies have

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also similarly reported higher sensitivity and accuracy for MRI in detection of fibroids in comparison to US[9,10] and of adenomyosis[11]. Certain imaging features have been described for adenomyosis like junctional zone thickness of 8 to 12 mm, greater than 5 mm difference in maximum and minimum junctional zone thickness and junctional zone thickness/total myometrial thickness more than 40% on MRI[3]. Mullerian duct anomalies represent congenital alterations in development of paramesonephric ducts with two-dimensional ultrasound as the initial imaging method used for evaluation, although it is highly operator dependent[12]. MRI is regarded as gold standard for mullerian malformations as it provides three-dimensional anatomical visualization[12,13].

In our study, we found that for malignant lesions of group 1, the sensitivity, specificity and accuracy were higher for MRI (92.3%, 94.9% and 93.9% respectively) as compared to US (76.9%, 91.5% and 85.7% respectively). The principal management of cervical carcinoma depends on the clinical and imaging staging[7]. Epstein et al[14] have reported high accuracy of US and MRI for initial stage of cervical malignancy. Transvaginal US along with transabdominal US is regarded as initial modality of choice for uterine malignancies; however, they are operator dependent with limited field-of-view[2]. Cervical malignancy appears as hypo-isoechoic lesion with ill-defined borders or as bulky cervix with heterogeneous echogenicity on US. TVS has good sensitivity (77%) is diagnosing parametrial invasion in cervical carcinoma and good accuracy in estimating tumor size[2,14].

On MRI, cervical zonal anatomy is nicely demonstrated on T2-weighted and contrast enhanced T1-weighted images appearing as innermost T2 hyperintense mucosa and secretions of cervical cavity, T2 hypointense mid layer of fibroblasts and smooth muscle and external intermediate intensity stromal layer[2]. Cervical malignant mass appears as hyperintense/ intermediate signal intensity lesion on T2-weighted image with diffusion restriction, low ADC value and early contrast enhancement. Parametrial invasion of cervical mass is detected by interruption of the T2 dark outermost stromal layer[7] with 87% sensitivity for detection of vaginal extension. Metastatic lymphadenopathy shows DWI hyperintensity with low ADC value[7]. Hence, MRI is recommended for presurgical imaging and staging[2].

Endometrial carcinomas are seen as isoechoic/ hyperechoic endometrial lesion on US, mildly hyperintense mass lesion on T2-weighted image and hypointense on early contrast enhanced T1-weighted image (compared to adjacent myometrium) with restricted diffusion and low mean ADC values (0.75 to 0.97 × 10−3 mm^2 /s)[7]. TVS has good accuracy (60-76%) in diagnosing myometrial extension in endometrial carcinomas[15] but it has curtailed field-of view and depth of visualization making the lymph nodal assessment difficult[7]. The presence of high signal on DWI image with low ADC value and irregular interface of endo-myometrial junction are indicators of endometrial malignancies[16].

The most frequent benign and neoplastic lesion in group 2 was pelvic inflammatory disease with its complications and ovarian neoplastic mass, respectively. We found that for benign lesions of group 2, the sensitivity, specificity and accuracy were higher for MRI (92.6%, 98.6% and 96.9% respectively) as compared to US (90.2%, 89.2% and 89.8% respectively). It was reported by Tukeva et al[17] that MRI has higher diagnostic sensitivity, specificity and accuracy (95%, 89%, and 93% respectively) compared to transvaginal US (81%, 78%, and 80% respectively) for benign ovarian lesions and Sofic et al[6] reported overall sensitivity as 80.8% for US and 94.6% for MRI. MRI diagnostic precision for benign adnexal lesions in

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our study is close to these studies; however, US diagnostic sensitivity and accuracy is less than our study which could be due to varied spectrum of adnexal lesions included in the studies. In regard to the malignant lesions of group 2, the sensitivity, specificity and accuracy were higher for MRI (94.6%, 96.7% and 95.9% respectively) as compared to US (78.4%, 93.4% and 87.8% respectively). The positive likelihood ratios were greater for MRI than for US and negative likelihood ratios were smaller for MRI than for US for the gynecological lesions studied by us which indicate higher performance of MRI comparatively. It was also found that there was substantial agreement between US and almost perfect agreement between MRI with final diagnosis suggesting relatively better performance of MRI.

US has been seen to have good specificity[18] for detection of benign cystic lesions and neoplastic ovarian masses as was seen in our study, However, MRI has been reported to be better in characterization and staging of undetermined complex cystic and solid ovarian lesions[4]. The malignant ovarian lesions have poor prognosis in females, approximately 10% of which seen in relation to familial syndromes[18], although benign ovarian lesions are commoner than malignant ovarian masses[1]. US has been recommended for first-line diagnosis of adnexal lesions with MRI favored for preoperative assessment of ovarian tumors[19]. It has been reported that for recurrent ovarian neoplasms, MRI has good sensitivity (90%), specificity (88%) and accuracy (89%)[20].

On US, the demonstration of irregularly thickened walls, locules with internal echoes and eccentric soft tissue nodules represent neoplastic ovarian lesion[4]. On MRI, there is added advantage of availability of DWI sequence showing restriction of diffusion and presence of enhancing nodules/ thick walls/ thick septations/ papillary projections on contrast enhanced T1-weighted sequence in neoplastic complex cystic ovarian lesions[21]. There is higher accuracy (83–91%) of MRI in differentiating neoplastic from benign ovarian lesions reported in previous study[4], which is close to our study. The use of fat-suppressed sequence on MRI helps to accurately detect fat component in the ovarian lesion (most common in dermoid cyst)[1,4,21]. US also has high sensitivity and specificity in correctly identifying dermoid cyst with characteristic feature of Rokitansky nodule[1,22]. US can easily diagnose hemorrhagic cyst showing presence of spider-web-like/ fish net internal blood contents[1] and typical endometriomas showing ground glass appearance. Hence, US is the primary diagnostic imaging choice. However, atypical cystic adnexal lesions are further evaluated with MRI[1]. Lesions having blood / blood products are well evaluated on MRI using gradient echo sequences helping in diagnosing hemorrhagic cysts and endometriomas[4,21].

Limitations: Pathohistology findings were not available for many patients with benign lesions as these cases were conservatively treated with follow-up. Transvaginal US was not done is all cases in our study, which could have increased the overall and individual sensitivity of diagnosis of gynecological lesions as transvaginal US are known to have higher resolution and better diagnostic accuracy compared to transabdominal US. We had included histopathologically proven malignant tumors in the study; however, correlation and agreement of staging on imaging with surgical and histological staging was not done. Further study will be required for correlation of imaging staging with pathohistological staging for neoplastic lesions.

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5. CONCLUSION

Imaging in gynecological diseases is indispensable for proper diagnosis, treatment and follow-up. Ultrasound is preferred as the primary modality for patients; however, it is operator dependent. MRI has higher accuracy and recommended for those lesions which are undecided on US.

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