Original Research Article

Utility of structural MRI and DWI in evaluation of uterine and adnexal lesions

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Abstract

Background: In females, uterine and adnexal pathologies have been the common cause of morbidity. Accurate diagnosis is of utmost importance for timely intervention, which can be done with good accuracy by Magnetic Resonance Imaging (MRI).Diffusion weighted imaging (DWI) is a functional imaging sequence which works on the principle of random mobility of water molecules within the tissues. MRI with DW Imaging emerged as an optimistic tool in detection and characterization of various uterine and adnexal lesions, their anatomical extension, understanding the pathophysiology by ADC values which further helps in differentiation of benign from malignant lesions. **Methods:** This was a prospective, observational study conducted at a tertiary center for over a period of 2 years with 100 patients of all age groups suspected of uterine and adnexal lesions, examined under Siemens Avanto Magnetic Resonance Imaging (1.5 Tesla). The mean differences in ADC between benign and malignant were compared using a student t-test. Accuracy of ADC Cut off value to differentiate benign from malignant lesions were assessed by Kappa statistic. **Results:** The mean ADC value for benign uterine lesions was 1.33 + 0.18 ×10-3 mm2/s and for malignant lesions was 0.77 + 0.08 ×10-3 mm^2/s with an ADC cut off value of $0.92\times10^{-3}mm^2/s$ was suggested for differentiating benign from malignant uterine lesions. The mean ADC value for benign adnexal lesions was 1.35 $\pm$78 $\times10^{-3}$ mm^2/s and for malignant lesions was 0.91 $\pm$ 0.03 $\times10^{-3}$ mm^2/s. Few benign lesions showed ADC values lower than malignant lesions. The mean ADC value for endometriomas was 0.69 $\pm$ 0.03 $\times10^{-3}$ mm^2/s and the mean ADC value for tubo-ovarian abscess was 0.46$\pm$ 0.06 $x\times10^{-3}$ mm^2/s. Hence statistically, ADC cut off value of $0.96\times10^{-3}mm^2/s$ was not significant in differentiating benign from malignant adnexal lesions with a kappa value of 0.3 and p-value of 0.37.From our study, the sensitivity, specificity, positive predictive, negative predictive value and accuracy of MRI in detecting and differentiating benign and malignant uterine and adnexal lesions was 95%, 100%, 100%, 98.72% and 99% respectively with a strong kappa value. **Conclusion:** From our study we have concluded that diffusion weighted imaging has a notable role in differentiating benign from malignant uterine lesions rather than adnexal lesions. However, irrespective of ADC values, a complete analysis of the lesions utilizing all sequences we had observed that MRI had a sensitivity, specificity and accuracy in detecting uterine and adnexal lesions.

Key words: Fibroid,adenomyosis,carcinoma cervix,ADC Values,bridging vessels,uterine,adnexal lesions

Introduction

In females, uterine and adnexal pathologies have been the common cause of morbidity. Although most of them being benign, malignant ones are associated with significant risk of mortality. Hence accurate diagnosis is of utmost importance for timely intervention, which can be done with good accuracy by Magnetic Resonance Imaging (MRI).Although ultrasonography (USG) is the mainstay in female pelvic pathologies, MRI is better used for evaluating female pelvic lesions on account of its good tissue resolution, multiplanar imaging capacity and excellent tissue differentiation ability which can help in making the definitive diagnosis[1].Adnexal masses whose origin and nature

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(cystic/solid) is difficult to be detected in USG are better evaluated by MRI because of its precision in characterising the lesion and defining the tissue of origin. MRI is therefore a critical imaging method for detecting uterine and adnexal lesions, and also for separating benign from malignant lesions[2].Diffusion weighted imaging (DWI) is a functional imaging sequence. It works on the principle of random mobility of water molecules within the tissues. Different tissues have variable water diffusion which provides a good image contrast and obviates the exogenous contrast administration[4]. Obtained DWI image is analysed qualitatively by using different strengths of diffusion sensitizing gradient (b-values) and quantitatively using Apparent Diffusion Coefficient (ADC) maps[3].MRI with DW Imaging emerged as an optimistic tool in detection and characterization of various uterine and adnexal lesions, their anatomical extension, understanding the pathophysiology by ADC values which further helps in differentiation of benign from malignant lesions[4].In our study we have evaluated the features of the various lesions of uterus and adnexa based on their appearance on T1WI, T2WI, STIR, T1FS, GRE, post contrast enhancement, diffusion restriction and ADC values.In addition, the accuracy of MRI in the identification and distinction of benign from malignant lesions was assessed on the basis of ADC values determined from the DWI sequence and verified by histopathological diagnosis.Therefore, we conducted this research to evaluate the role of Diffusion Weighted Imaging and MRI in identifying uterine and adnexal lesions and distinguishing between benign and malignant lesions.

Material and methods

This was a prospective, observational study conducted at a tertiary centre for over a period of 2 years from September 2018 to August 2020. A total 100 patients of all age groups were included, who were suspected of uterine and adnexal lesions. Examination was done under Siemens Avanto Magnetic Resonance Imaging (1.5 Tesla). Proper safety measures were taken. Postoperative and post radiation therapy patients, congenital anomalies of uterus and pregnant patients with adnexal masses were excluded from our study. Institutional Ethical Committee (IEC) clearance was obtained before conducting the study. Informed and written consent was obtained from all the patients.

MRI scan technique: Patient positioned supine with head towards the magnet.Body coil placed over abdomen and pelvis and secured using straps. Beam centering done over the iliac crest.Planes and sequences used included: T1 Weighted Imaging (T1WI) - axial, coronal planes, T2 Weighted Imaging (T2WI) - axial, coronal and sagittal planes, Diffusion weighted sequence (DWI) in axial plane, Short TI Inversion Recovery (STIR) in axial, coronal, sagittal planes, T1-Fat supressed (FS) in axial plane, Gradient Echo (GRE) in sagittal or axial plane and contrast was used whenever required with a slice thickness of 5mm.

Data collection method and statistical analysis: Continuous variable like age and ADC were expressed as mean (standard deviation). The association of ADC with type of lesion (benign and malignant) were separately assessed for both uterine and adnexal lesions, using a chi-squared test. The mean differences in ADC between benign and malignant were compared using a student t-test. Receiver operating characteristic (ROC) curve of the ADC values used for differentiating benign from malignant lesions, plotted separately for both uterine and adnexal lesions. Accuracy of ADC Cut off value to differentiate benign from malignant lesions were assessed by Kappa statistic. A p value of less than 0.05 was considered as statistically significant.

Results

Patients in our study varied from 9 to 72 years of age. The mean age for benign and malignant uterine lesions was 41.9($\pm$8.2) years and 57.1($\pm$12.3) years respectively. The mean age for benign and malignant adnexal lesions was 38.6($\pm$12.3) years and 50.1($\pm$ 8.5) years respectively.In our study, 54/100 cases were uterine and cervical lesions and 46/100 were adnexal lesions. Among uterine and cervical lesions 32 (57.4%) were fibroids, 7(12.9%) were adenomyosis and adenomyomas, 3(5.6%) were carcinoma endometrium and 12(22.2%) were carcinoma cervix. Among adnexal lesions, 36(78.2%) lesions were ovarian including – [8 (17.4%) endometriomas, 6(13%) serous cystadenomas, 3(6.5%) mucinous cystadenomas, 3 (6.5%) haemorrhagic cysts, 3(6.5%) simple ovarian cysts, 3(6.5) mature teratomas, 1(2.2%) fibrothecoma, 1(2.2%) ovarian torsion and 8(17.4%) ovarian carcinomas] and 10(21.8%) lesions were extra-ovarian in origin including– [5(10.9%) tubo-ovarian abscess, 3(6.5%) hydrosalpinx and 2(4.4%) paraovarian cyst.]77/100 cases were benign and 23/100 were malignant. Among 54 uterine lesions, 39(72.2%) were benign and 15(27.8%) were malignant lesions. Carcinoma cervix constituted maximum with 12/15 cases of malignant lesions. Among the 46 adnexal cases, 38(82.6%) were benign and 8(17.4%) were

malignant.On division of adnexal lesions into solid, cystic and solid-cystic based on appearance,6/8 malignant lesions showed predominantly solid-cystic appearance on MRI and majority of benign lesions showed cystic appearance, which was helpful in differentiation of malignant from benign lesions with a significant P value of <0.001(Table- 1)

Blood containing benign lesions in our study included (8) endometriomas, (3) hemorrhagic cysts – Both these lesions show blooming on GRE and chronic cases showing diffusion restriction with no post contrast enhancement. T2 dark spot sign was seen in 4/8(50%) of endometriomas and 0/3 hemorrhagic cysts. T2 shading sign was seen in 7/8(87.5%) of endometriomas and 1/3(33.3%) of hemorrhagic cysts.

T2WI: In our study all malignant uterine lesions appeared hyperintense on T2WI. Out of 39 benign uterine and cervical lesions, 31(79.5%) showed hypointense signal and 8(20.5%) showed hyperintense signal characteristics. **T1WI**: Out of 38 benign adnexal lesions, 20(52.6%) showed hypointense, 13(34.2%) hyperintense and 5(13.2%) showed isointense signal characteristics. **T1FSC+:** In our study, contrast was given in 30 uterine lesions and 27 adnexal lesions. Out of 30 uterine lesions all the 15 malignant lesions showed heterogeneous contrast enhancement and none of benign lesions showed enhancement. Out of 27 adnexal lesions, 57.9% benign cases showed no contrast enhancement, 26.3% benign lesions showed peripheral contrast enhancement, 15.8% benign lesions showed enhancing septae, 87.5% malignant lesions showed heterogeneous post contrast enhancement and 12.5% malignant lesions showed enhancing septae.

Diffusion weighted imaging was done in all the cases and ADC values were calculated at a 'b value of 800' wherever required. In our study 0/39 benign uterine lesions, and 15/15 malignant uterine lesions showed diffusion restriction (table-2).The mean ADC value for benign uterine lesions was 1.33 $\pm$ 0.18 $\times10^{-3}$ mm^2/s and for malignant lesions was 0.77 $\pm$ 0.08 $\times10^{-3}$ mm^2/s. Receiver operating characteristic (ROC) curve of the ADC value was plotand ADC cut off value of $0.92\times10^{-3}mm^2/s$ was suggested for differentiating benign from malignant uterine lesions with a sensitivity, specificity, positive predictive and negative predictive value of 100%.In our study out of 38 benign adnexal lesions, 17(44.8%) lesions showed diffusion restriction, 21(55.2%) showed no restriction and all 8 malignant lesions showed diffusion restriction (table-2).The mean ADC value for benign adnexal lesions was 1.35 $\pm$ 0.78 $\times10^{-3}$ mm^2/s and for malignant lesions was 0.91 $\pm$ 0.03 $\times10^{-3}$ mm^2/s. Receiver operating characteristic (ROC) curve of the ADC value was plot and ADC cut off value of $0.96\times10^{-3}mm^2/s$ was suggested for differentiating benign from malignant adnexal lesions.

8(47%) endometriomas and 4(23.5%) tubo-ovarian abscesses are showing diffusion restriction with low ADC values.The mean ADC value for endometriomas was 0.69$\pm$ 0.03 $\times10^{-3}$ mm^2/s and the mean ADC value for tubo-ovarian abscess was 0.46$\pm$ 0.06 $x\times10^{-3}$ mm^2/s

Hence statistically, ADC cut off value of $0.96\times10^{-3}mm^2/s$ was not significant in differentiating benign from malignant adnexal lesions with a kappa value of 0.3 and p-value of 0.37, with sensitivity, specificity, positive predictive and negative predictive values of 100%, 55.2%, 32%, and 100%.In our study, correlation of MRI finding was done with histopathology (HPE), post-operative findings, and biochemical parameters, follow up diagnosis and other modalities like ultrasound wherever possible. When correlation of MRI diagnosis was done with the ultimate proven diagnosis, out of 100 proved cases MRI diagnosed 99 cases correctly. From our study, the sensitivity, specificity, positive predictive, negative predictive value and accuracy of MRI in detecting and differentiating benign and malignant uterine and adnexal lesions was 95%, 100%, 100%, 98.72% and 99% respectively with a strong kappa value.

Discussion

Uterine and adnexal lesions in the females constitute major cause of morbidity. Detailed evaluation of pathologies under suspicion in USG has to be done with MRI. Benign lesions are found in younger age group and malignant lesions in elderly. Prasad et al. observed that benign lesions were prevalent in < 50 years age group and malignant lesions were commonly seen in > 50 years age group[5]. MRI helps in accurate localization of uterine and adnexal lesions which were in doubt on USG. In comparison of uterine, cervical and adnexal lesions, more malignant lesions (15/23) were noted arising from cervix.Kochiyil et al. Dr Divyshree et al. had observed maximum number of lesions was of uterine followed by adnexal. Among the uterine lesions fibroids are highest in number followed by carcinoma cervix[1,2]. Most common lesions in benign uterine and adnexal lesions were uterine fibroids, followed by epithelial benign ovarian tumors. Pedunculated large sub serous fibroids and adnexal solid masses may lead to diagnostic dilemma on USG, which we can successfully overcome utilizing bridging vessel sign (figure -1) on MRI. Bridging vessels appear as curvilinear tortuous flow voids between the mass in question and uterus. Sub serosal fibroids with size greater than 3cm has a high sensitivity and specificity

in diagnosis[6].On division of adnexal lesions into solid, cystic and solid-cystic, we observed that malignant lesions showed predominantly solid-cystic appearance on MRI, which is helpful in differentiation from benign lesions. Our results are corroborated well with the study conducted by Prasad et al, where they had observed that benign lesions are predominantly cystic and malignant lesions as solid- cystic[5].We observed that malignant cervical and uterine lesions showed high signal intensity on T2W sequence owing to their high cellularity, while benign lesions predominantly showed low signal intensity. Hence T2WI (figure -2) can be better utilized for detecting the malignant uterine and cervical lesions. T1WI hyperintense lesions in our study, included fat and blood containing lesions like - endometriomas, hemorrhagic cysts and mature cystic teratomas. Diagnostic approach to T1WI hyperintense adnexal lesions was shown in figure-3. We observed that post contrast imaging can be best utilized for detecting and differentiating benign and malignant uterine and adnexal lesions.Malignant uterine and cervical lesions showed diffusion restriction with low ADC values with a significant difference in the ADC values between, normal tissue, benign lesions and malignant lesions. O. Kilickesmez et al. observed a statistically significant difference in the ADC values of normal myometrium, endometrium and endometrial carcinomas. There is a significant difference in the ADC malignant and benign lesions showing mean ADC values 1.05± 0.11 and 1.55± 0.33 respectively with a P value of < 0.01. A cut-off value for malignant lesions $1.05x\times10^{-3}$ mm^2/s yielded a sensitivity, specificity, and accuracy of 95.83%, 94.55%, and 94.94%, respectively[7]. Various studies conducted by Dhanda et al. Coutinho et al. Lucas et al. Xuewang et al. and RC Jha et al. demonstrated that ADC measurements can quantitatively distinguish between normal and malignant uterine lesions[4,8-11].Carcinoma cervix (figure -4) is the second most common after carcinoma breast. The modality of choice for the assessment of tumour size and its spread is MRI[12]. The MRI has a high negative predictive value (NPV) of 95 percent for parametrial invasion in cervical carcinoma[13].It was documented that a 100% NPV of MRI for urinary bladder or rectal invasion can obviate the necessity of invasive procedures and in turn reduces staging costs and morbidity[14]. Sh. Naganawa et al. observed that cervical carcinoma has been shown to demonstrate impeded diffusion relative to normal cervical stroma, and a significantly lower ADC has been reported in cervical carcinoma ($1.09 \pm 0.2 \times 10^{-3}$ mm^2/sec) compared with the normal cervix ($1.79 \pm 0.24 \times 10^{-3}$ mm^2/sec)[15].Endometrial carcinoma (figure-5) is less common in India in comparison to western countries, which is evident in our study with less number of cases in comparison to carcinoma cervix. MRI assists in the assessment of myometrial invasion depth, cervical invasion and nodal metastasis[16].Shigenobu Motoshima et al. observed a likelihood of 22% of lesions with restricted diffusion might be benign and suggested an ADC value of $1.4x10^{-3}mm^2/sec$ and $1.15x10^{-3}mm^2/sec$ for differentiating between normal and cancerous tissue in uterus and endometrium respectively[17].In case of adnexal lesions, maximum malignant lesions and few benign lesions show diffusion restriction with low ADC which values. Koc et al. had observed that mean ADC values of malignant lesions were significantly lower than those of benign lesions for all b values ($P < 0.005$)[18].Endometriomas, hemorrhagic cysts and tubo-ovarian abscesses constitute the majority of benign lesions which shows diffusion restriction. T2 shading sign (Figure-6) and T2 dark spot sign are helpful in differentiation of endometriomas from hemorrhagic cysts. Corwin et al concluded that T2 dark spot sign has high specificity for chronic haemorrhage and is useful to differentiate endometriomas from haemorrhagic cysts. The T2 shading sign is sensitive but not specific for endometriomas[19]. Hence, use of DWI sequence alone cannot differentiate endometriosis and tubo-ovarian abscesses from malignant lesions. Additional sequences like T1WI, T2WI and T1FSC+ are required for complete evaluation and differentiation. Tubo-ovarian abscess (Figure-7) will show peripheral contrast enhancement on T1FSC+ images, which helps in ruling out malignancy. Chandanalall et al reported that decisions based on the appearance of DWI and ADC values alone may lead to ovarian tumours being misclassified as benign or malignant[20].

Conclusion

MRI is an exceptional modality in detecting and characterizing the uterine and adnexal lesions. It plays a crucial role in identification, characterization and classification of various uterine and adnexal lesions. We inferred from our research that diffusion weighted imaging plays a significant role in separating benign from malignant uterine lesions with an ADC cut off value of 0.92×10^{-3}mm2/s along with 100% sensitivity and specificity. In adnexal lesions, diffusion restriction can be seen in both benign and malignant lesions. Benign lesions include endometriomas and tubo-ovarian abscesses. Hence, DWI has a limited role in case of adnexal lesions, because a wide range of benign

adnexal lesions showed low ADC values. However, irrespective of ADC values, a complete analysis of the lesions utilizing all sequences we had observed that MRI had a sensitivity, specificity and accuracy 95%, 100% and 99% in detecting uterine and adnexal lesions.

Table 1: Distribution of benign and malignant adnexal lesions into solid/cystic/solid-cystic (n=46)

Lesion	Cystic		Solid		Solid-cystic		Total
	n	**%**	**n**	**%**	**n**	**%**	
Benign	33	86.8	2	5.3	3	7.9	38
Malignant	2	25.0	0	-	6	75.0	8
Chi square value: 18.95, P value: <0.001							

Table 2: Distribution of benign and malignant lesion on diffusion restriction

Lesion	Absent		Present		Total	Chi square value	P value
	n	%	n	%			
Uterine and cervical lesions						53	<0.0001
Benign	39	100	0	-	39		
Malignant	0	0	15	100	15		
Adnexal lesions						7.9	0.0048
Benign	21	55.2	17	44.8	38		
Malignant	0	0	8	100.0	8		

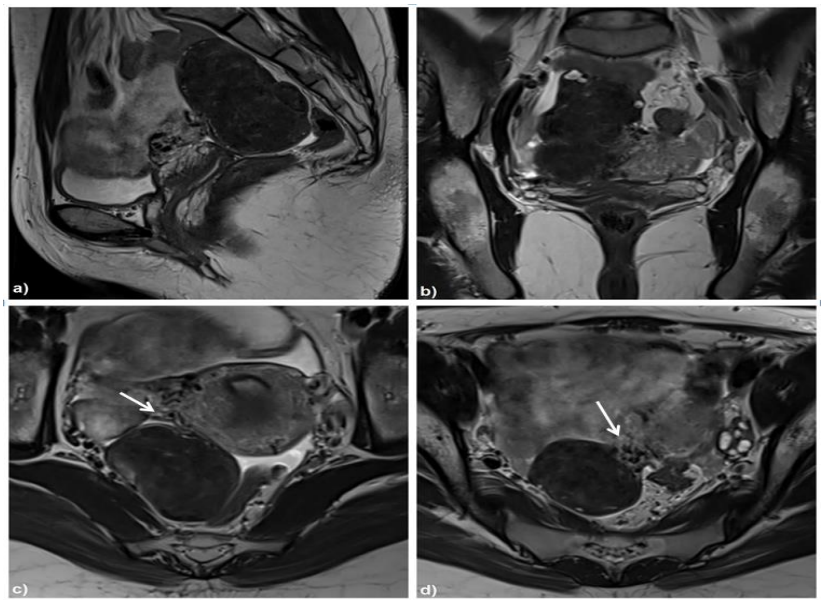

Fig 1: MRI pelvis showing a large uterine subserosal fibroid; a) & b) Sagittal & coronal T2W images showing a large hypointense lesion in the right adnexa. Right ovary is seen separately from this lesion. c) & d) are axial T2W images showing bridging vessels (arrow) between the lesion and right postero-lateral wall of uterus confirming sub serous fibroid.

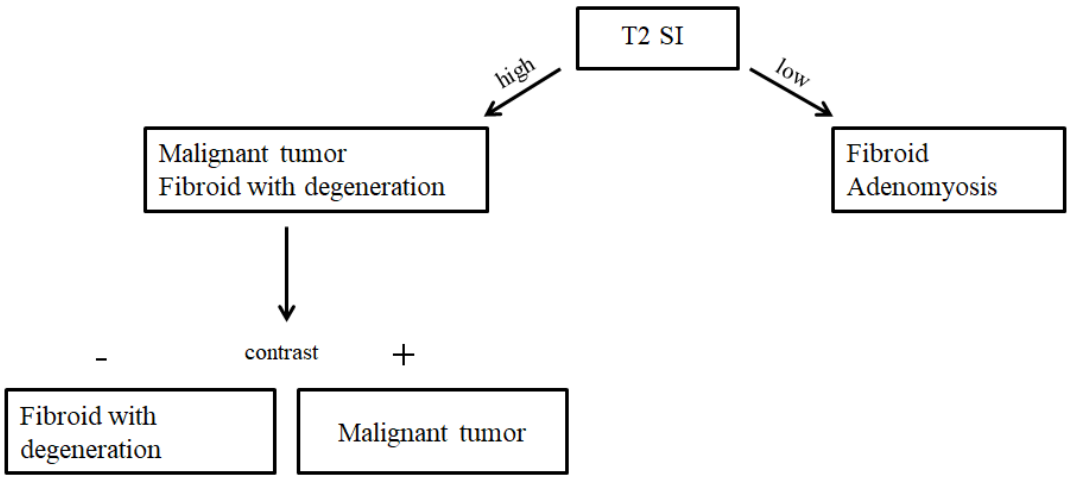

Fig 2: Diagnostic approach to uterine lesions based on T2WI signal intensity (SI= signal intensity)

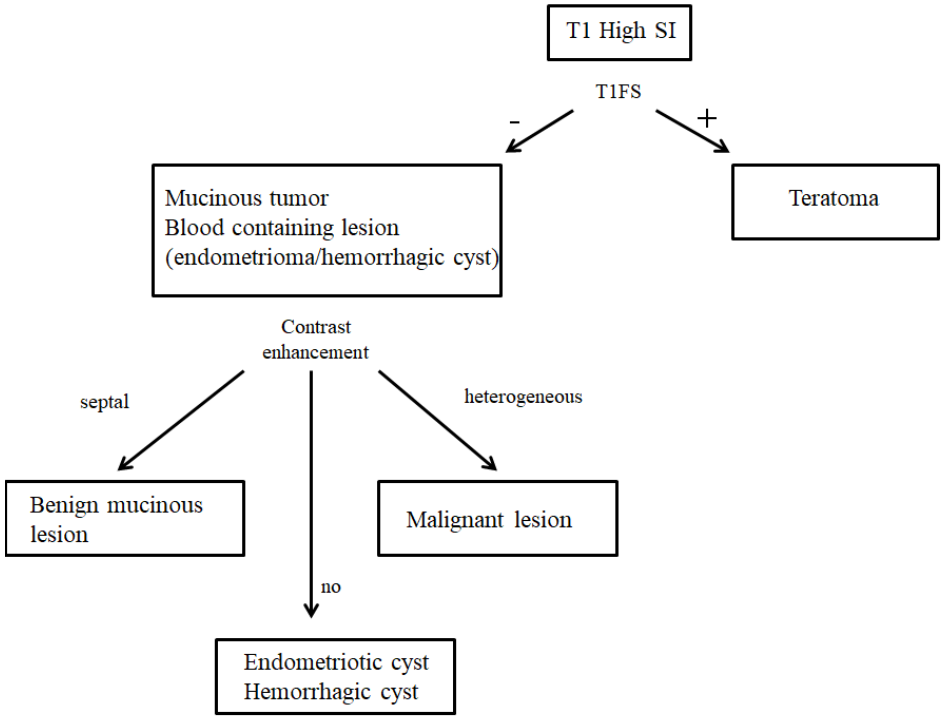

Fig 3: Diagnostic approach to adnexal lesions showing hyperintense signal on T1WI. (SI= signal intensity)

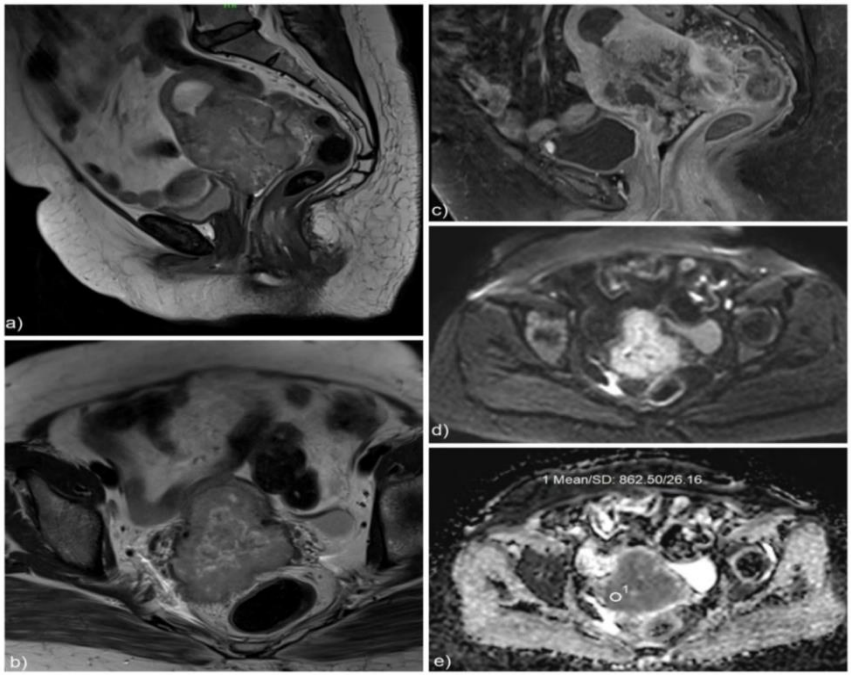

Fig 4: MRI pelvis showing moderately differentiated squamous cell carcinoma cervix; a) Sagittal T2W image showing bulky cervix with a large hyperintense lesion with irregular and poorly defined margins; b) Axial T2W image showing extent of the lesion invading bilateral parametria and mesorectal fat planes; c) Sagittal post contrast T1FS image showing heterogeneous enhancement of the lesion with few non-enhancing necrotic areas; d) & e)are b value and ADC images of diffusion weighted imaging, showing peripheral diffusion restriction, with corresponding low ADC value of 0.86 × $10^{-3}$$mm^2$/s.

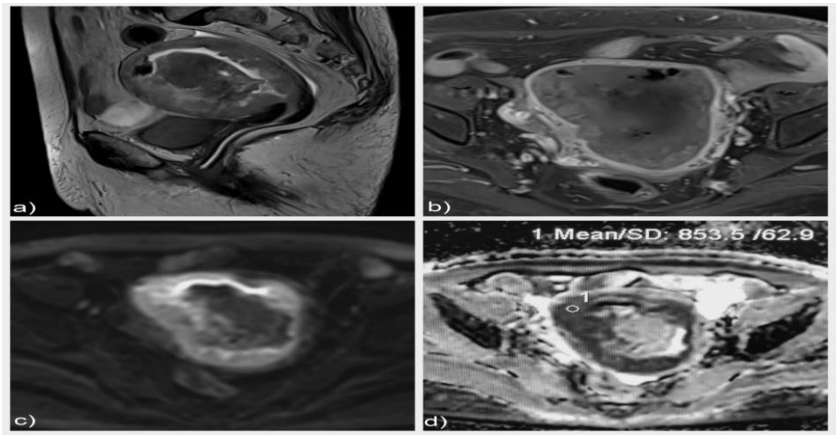

Fig 5: MRI pelvis showing endometrial carcinoma; a) Sagittal T2W image showing bulky uterus with irregular heterogeneously hyperintense endometrial growth along the anterior uterine wall; Few areas of signal loss are seen– calcific foci;b) axial post contrast T1FS images showing heterogeneous predominantly peripheral enhancement of the lesion.c) &d)b value and ADC images of diffusion weighted imaging, showing peripheral diffusion restriction, with corresponding low ADC value of 0.85 × $10^{-3}$$mm^2$/s.

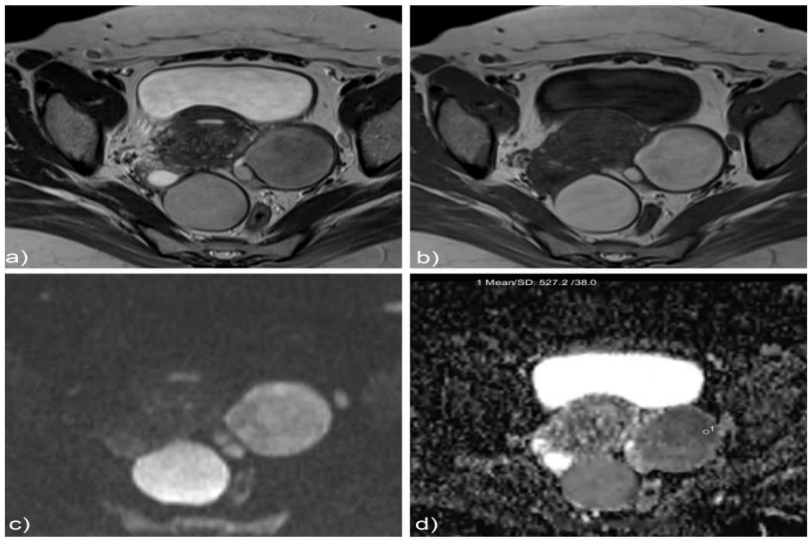

Fig 6: MRI pelvis showing bilateral ovarian endometriotic cysts; a) Axial T2W image showing two well defined, hyperintense cystic lesions in both ovaries showing T2 shading sign; b) Axial T1WI these lesions are appearing hyperintense; c) &d)b value and ADC images of diffusion weighted imaging, showing diffusion restriction, with corresponding low ADC value of 0.52 × $10^{-3}$$mm^2$/s.

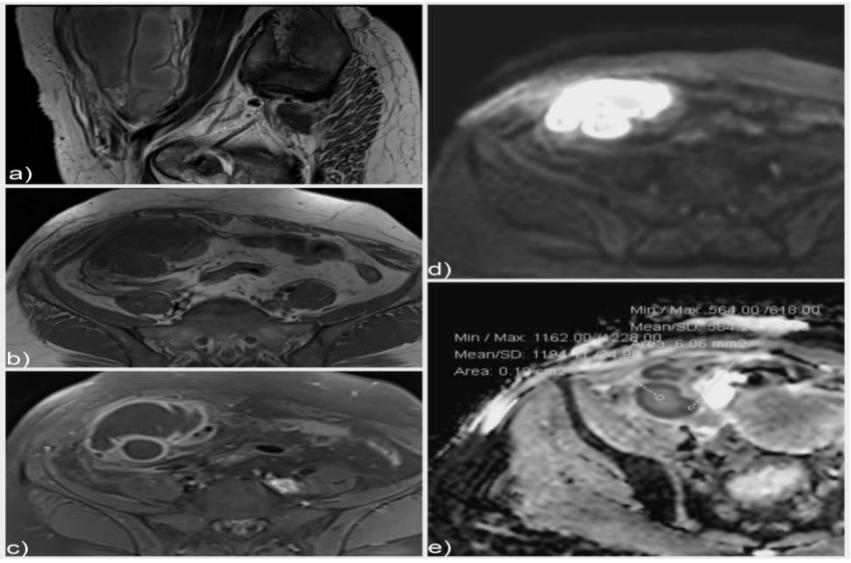

Fig 7: MRI pelvis showing tubo-ovarian abscess of right adnexa; a) On sagittal T2W images a large retort shaped lesion seen in right adnexa showing peripheral hyperintense signal and central low signal intensity content (necrosis); b) On axial T1W image this lesion is appearing hypointense; c) On T1FSC+ image this lesions shows peripheral rim enhancement. d) &e) are b value and ADC images of diffusion weighted imaging, where the necrotic components of the lesion are showing diffusion restriction, with corresponding low ADC value of 0.58 × $10^{-3}$$mm^2$/s.

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