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ORIGINAL RESEARCH

A study to evaluate the role of dynamic contrast enhanced magnetic resonance imaging and diffusion weighted imaging in evaluation of ovarian tumors

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ABSTRACT
Aim: The aim of the present study was to assess the ability of Dynamic contrast-enhanced MRI (DCE–MRI), and Diffusion-weighted image (DWI) to describe uncertain ovarian masses.
Methods: The present study was conducted in the Department of Radio Diagnosis and we did transabdominal ultrasound and transvaginal ultrasound for all cases. We investigated 50 patients with 50 adnexal lesions.
Results: The patients age is in the range from 20 to 78, with a mean of 43.56. The Patients were worried most about stomach pain and distension. Some cases showed sub-fertility or abnormal vaginal hemorrhage. Histopathology showed 21 benign, 4 borderline and 25 malignant tumors. The age range of patients diagnosed with benign tumors was 20-65 years, with a mean age of 39 ± 13 years. However, patients with malignant tumors had an average age of 46 ± 16.953 years, with a mean age of 78 years. The benign tumours included seven serous cystadenoma, six mucinous, three mature cystic teratoma, two ovarian fibromas and fibrothecomas, and one tubo-ovarian abscess. We found four borderline tumors-two serous and two mucinous. The study found 25 invasive malignant masses, including nine serous cyst-adenocarcinomas, six mucinous cysts, three metastatic krukenburgs, three immature teratomas, two fibro sarcomas, and two clear cell carcinomas.
Conclusion: DCE-MRI and DWI have accepted ability to distinguish between benign and malignant ovarian mass.
Key words: Ovarian, contrast, diffusion, MRI

INTRODUCTION

Ovarian tumours are a collection of cancerous growths that exhibit a diverse range of characteristics, depending on the exact type of tumor. The various subtypes can be classified into three categories: benign, low-malignant potential/borderline, and malignant [1-3]. The classification of ovarian masses based on their histogenetic principles was established by the World Health Organization (WHO). This classification system distinguishes between ovarian masses originating from coelomic surface epithelial cells (75% of all ovarian neoplasms), germ cells (15-20%), and mesenchyme (the stroma and the sex cord; 5-10%). Ovarian neoplasms, which typically originate from breast, colon, endometrial, stomach, and cervical malignancies, account for around 5% of metastatic lesions [4].

Despite being the primary imaging modality for suspected adnexal masses, ultrasonography (US) exhibits limitations in terms of characterization and staging[5]. MRI plays a crucial and well-established role in identifying and determining the stage of gynecological cancer. MRI's exceptional soft tissue resolution enables precise visualization of tumor dimensions, positioning, spread, and nodal engagement. Although conventional T1 and T2 sequences have been widely used in clinical settings, they are not effective in providing information about the tumour microenvironment. Additionally, they have limitations in evaluating the response of tumours to therapy, especially in distinguishing between residual or recurrent disease and post-treatment fibrosis due to the similarity in their morphological appearances[6].The aforementioned differentiation is vital in identifying patients who could potentially get advantages from further salvage treatment alternatives. Functional magnetic resonance imaging (fMRI) has advanced in recent years due to advancements in field strengths, receiver coils, and pulse sequences. This technology has demonstrated its advantages in the detection of brain, breast, and rectal malignancies[7].The clinical application of functional magnetic resonance imaging (fMRI) in the context of gynaecological cancer remains unestablished. However, a growing amount of evidence has emerged to substantiate its application in evaluating the response of tumours to therapy, yielding encouraging outcomes thus far, notably in the context of cervical cancer.

MR imaging has demonstrated exceptional precision in identifying and differentiating adnexal masses. Specifically, contrast-enhanced magnetic resonance imaging (MR) can accurately portray the inherent structure of the lesion with exceptional precision[8].The diagnostic accuracy of these masses has been improved by the utilization of dynamic enhanced imaging (DCE-MRI), which possesses the ability to analyse tumour microcirculation and angiogenesis in malignant tumours[9, 10].The quantitative examination of blood flow and vascular permeability is facilitated by the leakage of contrast media from capillaries into the extravascular extracellular space[11].The utilisation of this technique facilitates the accurate characterization of the internal structure, demarcation of necrotic regions, identification of solid constituents, examination of papillary projections, septations, and peritoneal implants[12].The utilisation of this technique is expected to have a significant impact on the assessment of ovarian cancer, since it serves as a predictive and prognostic instrument[13].Previous studies investigating the efficacy of Diffusion-weighted imaging (DWI) in the detection of malignant ovarian tumours have yielded inconclusive results[14, 15].Subsequent studies have demonstrated the utility of DWI in distinguishing between benign and malignant ovarian masses[7, 16, 17].A subsequent investigation revealed a sensitivity rate of 84% and a specificity rate of 89%[18].

This study aimed to evaluate the efficacy of dynamic contrast-enhanced MRI (DCE-MRI) and Diffusion-weighted imaging (DWI) in accurately describing ovarian masses with unknown characteristics.

MATERIALS AND METHODS

The present study is a Hospital based observational study conducted in the Department of Radio Diagnosis at Government General Hospital Srikakulam for a period of one year and we did trans-abdominal ultrasound and trans-vaginal ultrasound for all cases. We investigated 50 patients with 50 adnexal lesions.

The International Ovarian Tumour Analysis (IOTA) guidelines were used for the purpose of characterizing ovarian masses. The magnetic resonance (MR) assessment was conducted using a 1.5 Tesla MRI equipment. The magnetic resonance imaging (MRI) evaluation encompassed T1WI, T2WI, post-contrast fat-suppressed T1WI, and DWI. DWI was conducted at b0, b500, and b1000. A comprehensive analysis was conducted. The MR assessment yielded data pertaining to the average size of the cyst or mass, the ADC value, and the morphological characteristics indicative of malignancy. An individual analysis was conducted to evaluate the diagnostic performance of conventional MRI, DCE-MRI, and DWI in characterizing ovarian masses/cysts. Histopathology is performed on masses following surgical procedures.

STATISTICAL ANALYSIS

All statistical calculations were done using SPSS (Statistical Package for the Social Science; SPSS Inc., Chicago, IL, USA) version 22 for Microsoft Windows. Data was spread over excel sheet and the results were statistically described in terms of mean ± standard deviation (± SD) and range, or frequencies (number of cases) and percentages wherever necessary, p value < 0.05 was considered statistically significant.

RESULTS

Table 1: Complaints and type of tumours assessed among the study participants

Variables	N%
Complaints	
Abdominal pain	45 (90)
Sub fertility or irregular vaginal bleeding	5 (10)
Histopathology of assessed masses	
Benign	21
Borderline	4
Malignant	25

The main complaint was abdominal pain and/or abdominal distension; other patients came with different symptoms such as sub fertility or irregular vaginal bleeding. The histopathology of the assessed masses were 21 benign, 4 borderline, and 25 malignant. The age range for patients with benign tumors was 20-65 years (mean 39 ± 13 years) while those with malignant tumors, their age range was 21-78 years (mean 46 ± 16.953 years).

Table 2: Different ADC values of the included masses among the study participants

	N	ADC Values
Benign n=21		1.2-2 × 10-3 mm2/sec
Serous cystadenoma	7	1.4-2 × 10-3 mm2/sec
Mucinous cysadenoma	6	1.3-1.5 × 10-3 mm2/sec
Mature cystic teratoma	3	1.2-1.5 × 10-3 mm2/sec
Ovarian fibroma	2	1.6-1.8 × 10-3 mm2/sec
Fibrothecoma	2	1.2 × 10-3 mm2/sec
Tubo-ovarian abscess	1	1.3 × 10-3 mm2/sec
Borderline n=4		
Serous	2	1.1-1.5 × 10-3 mm2/sec
Mucinous	2	1.2 × 10-3 mm2/sec
Malignant n=25		0.7-1.2 × 10-3 mm2/sec
Serous cyst-adenocarcinoma	9	0.7-1 × 10-3 mm2/sec
Mucinous cyst-adenocarcinoma	6	0.9 × 10-3 mm2/sec
Metastatic krukenburg	3	1.2 × 10-3 mm2/sec
Immature teratoma	3	0.9 × 10-3 mm2/sec
Fibrosarcoma	2	1.1 × 10-3 mm2/sec
Clear cell carcinoma	2	0.8-0.9 × 10-3 mm2/sec

Benign masses included seven serous cystadenoma, six mucinous cystadenoma, three mature cystic teratoma, two ovarian fibroma, and fibrothecoma, and one tubo-ovarian abscess. There were four Borderline tumors (two serous and two mucinous). There were 25 invasive malignant masses (Nine Serous cyst-adenocarcinoma, six Mucinous cyst-adenocarcinoma, three Metastatic krukenburg, three immature teratoma, two fibro sarcoma, and two clear cell carcinoma). ADC values of malignant tumors showed a minimum of 0.7 × 10-3 mm2/s and a maximum of 1.2 × 10-3 mm2/s. The mean (±SD) was 1.01 × 10-3 mm2/s (±0.34), while ADC values of the benign masses showed a minimum of 1.2 × 10-3 mm2/s and maximum of 2 × 10-3 mm2/s with mean ±SD 1.6 × 10-3 mm2/s (±0.27).

Table 3: Analysis of the ovarian lesions size among the study participants

Dimension	Benign	Borderline	Malignant
Minimum	4.5 cm	6 cm	7 cm
Maximum	15 cm	22 cm	25 cm
Mean ± SD	9.7 ± 3.3	14 ± 7.3	13.7 ± 5.08

The malignant and borderline ovarian lesions were bigger in size than the benign lesions.

Table 4: The performance of the preoperative diagnosis in the study participants

	Ultrasound	Conventional MRI	DCE-MRI	DWI
TP	20	23	24	26
FN	6	3	2	0
FP	6	5	2	1
TN	12	13	16	17
Sensitivity	76.9 %	88.5 %	92.3 %	100 %
Specificity	66.6 %	72.2 %	88.8 %	94.4 %
PPV	76.9 %	82.1 %	85.7 %	96.3 %
NPV	66.6 %	81.2 %	88.8 %	100 %
Accuracy	81.8 %	81.8 %	90.9 %	97.7 %

The sensitivity, specificity, positive predictive value, negative predictive value, and accuracy for DWI were 100%, 94.4%, 96.3%, 100%, and 97.7% respectively. The performance of DWI was higher than the conventional MRI and DCE-MRI.

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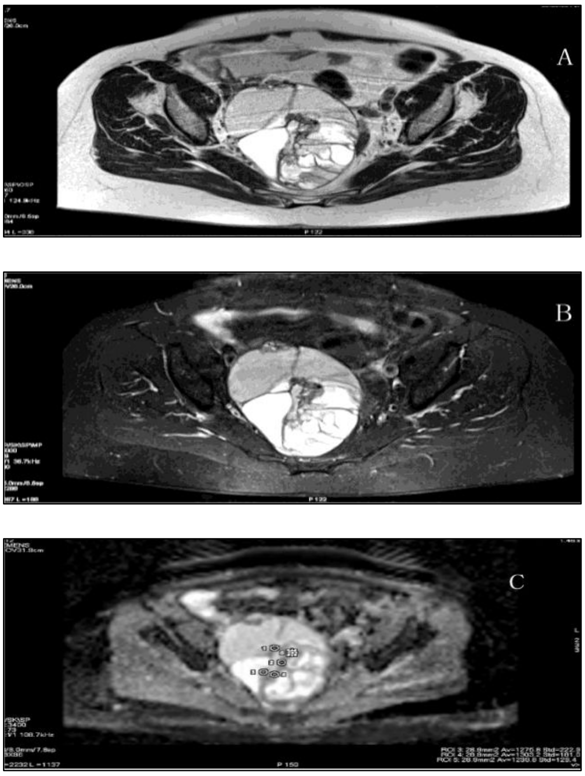

Fig 1: (A): A large primary ovarian multicystic tumor on T2-weighted; (B): on T2 STIR; (C): Diffusion-ADC maps. Small ROI is placed on a region appearing to be the most enhancing solid part of the tumor.

Fig 2 **2(A)**

Fig 2: Coronal T2W MRI image of the pelvis showing bilateral adnexal lesions with hyper intense signal on right side and heterogeneous signal on left side.

Fig 2: (A): Axial T2W MRI image of the same patient showing heterogeneous lesion with hypo intense solid component and hyper intense cystic component on right side and is crossing the midline. Heterogeneous signal lesion noted in left adnexa. Both ovaries not visualized separately-Bilateral Mucinous cystadenocarcinoma of ovary. An enlarged left Para iliac lymph node is identified.

DISCUSSION

MRI plays a crucial and well-established role in identifying and determining the stage of gynecological cancer. MRI's exceptional soft tissue resolution enables precise visualization of tumourdimensions, positioning, spread and nodal engagement. Although conventional T1 and T2 sequences have been widely used in clinical settings, they have certain limitations in assessing tumour micro environment and evaluating tumour response to therapy. Specifically, they struggle to distinguish between residual or recurrent disease and post-treatment fibrosis due to the similarity in morphological appearances[20].Functional magnetic resonance imaging (fMRI) has advanced in recent years due to advancements in field strengths, receiver coils, and pulse sequences. This technology has demonstrated its advantages in the detection of brain, breast, and rectal malignancies[21].

The conventional magnetic resonance imaging (MRI) technique evaluates the morphological characteristics of the lesion, including wall thickening, intra luminal papilla, mural nodules, thick septae, and signal strength on T1WI and T2WI. None of the aforementioned criteria exhibit consistent ability to distinguish between benign and malignant tumours. The advancement of innovative MRI techniques such as DCE MRI and DWI enhances the diagnostic accuracy of MRI[2].An individual analysis was conducted to evaluate the diagnostic performance of conventional MRI, DCE-MRI, and DWI in characterizing ovarian masses/cysts. The conventional MRI demonstrated a sensitivity of 88.5% and a specificity of 72.2%. This aligns with a meta-analysis examining the efficacy of magnetic resonance imaging (MRI) in the characterization of ovarian masses or cysts in women who have received inconclusive ultrasound evaluations. The sensitivity and specificity were determined to be 76% and 97%, respectively. The DCE-MRI demonstrated a sensitivity of 92.3% and a specificity of 88.8%. In our investigation, this method exhibits a favorable comparison to conventional MRI. The inclusion of DCE in the MRI enhanced the precision of the evaluation. The findings of the systematic review indicate that DCE-MRI exhibits a sensitivity of 81% and specificity of 98%[22].Nevertheless, a more recent study demonstrated a sensitivity of 83% and a specificity of 75%[23].The intensity of enhancement was found to be higher in malignant masses compared to benign lesions. The distinction was more pronounced at the initial stage of the contrast research than to the later stage[24, 25].

The results of our investigation indicate that DWI exhibits a sensitivity of 100%, specificity of 94.4%, PPV of 96.3%, NPV of 100%, and accuracy of 97.7%. DWI exhibited superior performance compared to conventional MRI and DCE-MRI. Our findings indicate that all malignant lesions, with the exception of one case of dermoid cyst, exhibited a strong signal on DWI. This can be attributed to the presence of keratinized material in the dermoid cyst. These findings align with the conclusions found in prior studies. The study demonstrated that the majority of the malignant ovarian masses and a portion of the dermoid cysts had significant intensity on DWI. The majority of benign lesions had a reduced signal strength on DWI[26, 27].

The study found that the average arterial diffusion coefficient (ADC) values for malignant lesions were 1.01 ± 10ℒ3 ± 0.34 mm2/s. The ADC measurements for benign lesions exhibited a mean value of 1.6 ± 10ℒ3 ± 0.27 mm2 per second. The threshold value we used was 1.2 ± 10ℒ3 mm2/s. This aligns with the conclusions drawn by Takeuchi et al. The average ADC value was determined to be 1.03 ± 10ℒ3 mm2/s in malignant tumours and 1.38 ^{2} 10ℒ3 mm2/s in benign tumours.25 A comprehensive meta-analysis of 16 studies has demonstrated that diffusion-weighted imaging (DWI) exhibits a sensitivity of 91% and specificity of 91% in differentiating between benign and malignant ovarian tumours[28].

CONCLUSION

The diagnostic capabilities of DCE-MRI and DWI in differentiating between benign and malignant ovarian masses are widely acknowledged. To present, a significant body of literature has examined the relationship between functional MRI and cervical cancer, yielding encouraging findings. Several studies have demonstrated the additional benefits of functional magnetic resonance imaging (fMRI) in cases of recurrent endometrial and ovarian malignancies. Due to its non-invasive nature, easy accessibility, and absence of ionizing radiation, both DCE-MRI and DWI-MRI offer advantages in tailoring and enhancing patient treatment.

CONFLICT OF INTEREST: None to be declared

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