

Assessment of Ovarian Tumors using Dynamic Contrast Enhanced Magnetic Resonance Imaging and Diffusion Weighted Imaging

Ram Kumar Gupta¹, Ashutosh Jha², Nain Kumar Ram³, Vijay Kumar⁴

¹Senior Resident, Department of Radio Diagnosis, Indira Gandhi Institute of Medical Sciences, Patna, Bihar, India

²Senior Resident, Department of Radio Diagnosis, Indira Gandhi Institute of Medical Sciences, Patna, Bihar, India

³Senior Resident, Department of Radio Diagnosis, Indira Gandhi Institute of Medical Sciences, Patna, Bihar, India

⁴Senior Resident, Department of Radio Diagnosis, Indira Gandhi Institute of Medical Sciences, Patna, Bihar, India

Received: 12-10-2022 / Revised: 07-11-2022 / Accepted: 19-01-2023

Corresponding author: Dr. Ashutosh Jha

Conflict of interest: Nil

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 at Department of Radio Diagnosis, Indira Gandhi Institute of Medical Sciences, Patna, Bihar, India for one year and we did transabdominal ultrasound and transvaginal ultrasound for all cases. We investigated 50 patients with 50 adnexal lesions.

Results: The patient's age ranged from 20 to 78 years old (mean 43.56 years). The main complaint was abdominal pain and/or abdominal distension; other cases came with different symptoms as subfertility 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). Benign masses included seven serous cystadenoma, six mucinous cysadenoma, 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 cystadenocarcinoma, six Mucinous cyst-adenocarcinoma, three Metastatic krukenburg, three Immature teratoma, two fibrosarcoma, and two clear cell carcinoma).

Conclusion: DCE-MRI and DWI have accepted ability to distinguish between benign and malignant ovarian mass.

Keywords: Ovarian, Contrast, Diffusion, MRI.

This is an Open Access article that uses a funding model which does not charge readers or their institutions for access and distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0>) and the Budapest Open Access Initiative (<http://www.budapestopenaccessinitiative.org/read>), which permit unrestricted use, distribution, and reproduction in any medium, provided original work is properly credited.

Introduction

Ovarian tumors are a group of neoplastic lesions showing a wide and varied

spectrum of features according to the specific tumor entity. They can be

categorized as benign, low-malignant potential/borderline and malignant subtypes. [1-3] The World Health Organization (WHO) provided classification of the ovarian masses based on their histogenetic principles, hence categorizing them with regard to their derivation from coelomic surface epithelial cells (75% of all ovarian neoplasms), germ cells (15–20%), and mesenchyme (the stroma and the sex cord; 5–10%). Metastatic lesions usually arising from breast, colon, endometrium, gastric and cervical cancers, constitute 5% of ovarian neoplasms. [4]

Ovarian masses become a diagnostic challenge, when proper categorization into benign or malignant masses can't be reached by imaging. [5] Accurate characterization is greatly valuable for appropriate patient's management, especially young women for whom conservation of fertility is mandatory and can be achieved via conservative surgical approaches. [6] Ultrasonography (US) shows limitations in characterization and staging despite being the first-line imaging modality for suspected adnexal masses. [7] Magnetic resonance (MR) imaging has shown great accuracy in the detection and discrimination of adnexal masses. In particular, contrast-enhanced MR can depict the lesion's intrinsic architecture with great detail. [8] Dynamic enhanced imaging (DCE-MRI) has added to the diagnostic accuracy of these masses, due to its capacity to characterize tumor microcirculation and angiogenesis in malignant tumors. [9,10] It depends on contrast medium leakage from capillaries into the extravascular extracellular space, therefore enabling quantitative analysis with information on the blood flow as well as vascular permeability. [11] It allows proper characterization of internal architecture, delineation of necrotic areas, solid components, papillary projections, septations, and peritoneal implants. [12] It is likely to play a major role in the

evaluation of ovarian malignancy, by acting as a predictive and prognostic tool. [13] Earlier reports on the ability of DWI to recognize malignant ovarian tumour have found that DWI is not useful. [14,15] Later reports found that DWI is useful in discrimination between benign and malignant ovarian mass. [7,16,17] A more recent study found a sensitivity of 84%, and a specificity of 89%. [18]

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.

Materials and Methods

The present study was conducted at Department of Radio Diagnosis, Indira Gandhi Institute of Medical Sciences, Patna, Bihar, India for one year and we did transabdominal ultrasound and transvaginal ultrasound for all cases. We investigated 50 patients with 50 adnexal lesions.

We pursue the International Ovarian Tumor Analysis (IOTA) rules to characterize ovarian mass. [19] MR assessment was done at the magnetic resonance unit. We used 1.5 Tesla machine with body coil as a transmitter and a receiver of radio frequency signals. The MR assessment included T1WI, T2WI, post-contrast fat-suppressed T1WI, and DWI. DWI was done at b0, b500, b1000. Descriptive analysis was done. Data from the MR assessment included the mean size of the cyst or mass, the ADC value, and the morphologic criteria suggesting malignancy. We had executed an individual analysis for conventional MRI, DCE-MRI and DWI concerning their diagnostic performance in the characterization of ovarian masses/cysts. Masses are sent for histopathology after operations.

Statistical analysis

All statistical calculations were done using SPSS (Statistical Package for the Social Science; SPSS Inc., Chicago, IL, USA) version 15 for Microsoft Windows. Data were statistically described in terms of mean \pm standard deviation (\pm SD) and range, or frequencies (number of cases) and percentages when appropriate. Comparison of numerical variables between the study groups was done using Student t test for independent samples. Chi

square (χ^2) test was performed for comparison of categorical data. Fisher exact test was used instead when the expected frequency was <5 . Accuracy was represented using the terms sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall accuracy. p Values $< .05$ Were Considered Statistically Significant.

Results

Table 1: Patient details

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 patient's age ranged from 20 to 78 years old (mean 43.56 years). The main complaint was abdominal pain and/or abdominal distension; other cases came with different symptoms as subfertility 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

	N	ADC Values
Benign n=21		
Serous cystadenoma	7	$1.2 - 2 \times 10^{-3}$ mm ² /sec
Mucinous cystadenoma	6	$1.3 - 1.5 \times 10^{-3}$ mm ² /sec
Mature cystic teratoma	3	$1.2 - 1.5 \times 10^{-3}$ mm ² /sec
Ovarian fibroma	2	$1.6 - 1.8 \times 10^{-3}$ mm ² /sec
Fibrothecoma	2	1.2×10^{-3} mm ² /sec
Tubo-ovarian abscess	1	1.3×10^{-3} mm ² /sec
Borderline n=4		
Serous	2	$1.1 - 1.5 \times 10^{-3}$ mm ² /sec
Mucinous	2	1.2×10^{-3} mm ² /sec
Malignant n=25		
Serous cyst-adenocarcinoma	9	$0.7 - 1.2 \times 10^{-3}$ mm ² /sec
Mucinous cyst-adenocarcinoma	6	0.9×10^{-3} mm ² /sec
Metastatic krukenburg	3	1.2×10^{-3} mm ² /sec
Immature teratoma	3	0.9×10^{-3} mm ² /sec
Fibrosarcoma	2	1.1×10^{-3} mm ² /sec
Clear cell carcinoma	2	$0.8 - 0.9 \times 10^{-3}$ mm ² /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 cystadenocarcinoma, six Mucinous cystadenocarcinoma, three Metastatic krukentburg, three Immature teratoma, two

fibrosarcoma, 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 (\pm 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 \pm SD 1.6×10^{-3} mm²/s (± 0.27).

Table 3: Analysis of the ovarian lesions size

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

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

Table 4: The performance of the preoperative diagnosis

	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.

Discussion

MRI has a pivotal and established role in detection and staging of gynaecological malignancy. The exquisite soft tissue resolution of MRI allows accurate demonstration of tumour size, location, extension and nodal involvement. Despite excellent clinical utilisation to date, conventional T1 and T2 sequences cannot provide information about tumour microenvironment and have limitations in

assessing response of tumours to therapy and in particular, differentiating residual or recurrent disease from posttreatment fibrosis due to overlap of morphological appearances. [20] Functional MRI has evolved over recent years with the development of stronger field strengths, receiver coils and pulse sequences and has proven benefit in cerebral, breast and rectal cancers. [21]

Conventional MRI assesses morphologic criteria of the lesion, such as wall thickening, intra luminal papilla, mural nodules, thick septae, and signal intensity on T1WI and T2WI. None of these criteria can consistently segregate benign from malignant lesions. Development of novel MRI modalities like DCE MRI and DWI

improves the diagnostic performance of MRI. [22] We had executed an individual analysis for conventional MRI, DCE-MRI and DWI concerning their diagnostic performance in the characterization of ovarian masses/cysts. We found that conventional MRI had 88.5% sensitivity and 72.2% specificity. This looks well with a meta-analysis of the value of MRI in characterization of ovarian mass/cyst in women with non-conclusive ultrasound evaluation. They found that the sensitivity and specificity was 76% and 97%, respectively. We found that DCE-MRI had 92.3% sensitivity and 88.8% specificity. This compares favourably to conventional MRI in our study. So, adding DCE to the MRI increased the accuracy of examination. Systematic review showed that DCE-MRI has 81% sensitivity and 98% specificity. [23] However, a more recent study showed 83% sensitivity and 75% specificity. [24] Malignant masses showed more intense enhancement than benign lesions. Difference was clearer in the early phase of the contrast study than the late phase. [25,26]

Our analysis revealed that DWI has 100% sensitivity, 94.4% specificity, 96.3% PPV, 100% NPV, and 97.7% accuracy. The performance of DWI was higher than conventional MRI and DCE-MRI. We found that all malignant lesions and one case of dermoid cyst demonstrated a high signal on DWI. This may be ascribed to keratinized substance in dermoid cyst. These results are consistent with the conclusions in the previous researches. They showed that most of the malignant ovarian masses and some of the dermoid cysts had high intensity on DWI. Most of the benign lesions had low signal intensity on DWI. [27,28]

In our study, the mean ADC values for malignant lesions were $1.01 \times 10^{-3} \pm 0.34$ mm²/s). The mean ADC values for benign lesions were ($1.6 \times 10^{-3} \pm 0.27$ mm²/s). Our cut-off value was 1.2×10^{-3} mm²/s. This agreed with findings by Takeuchi et

al. They found the mean ADC value was 1.03×10^{-3} mm²/sin malignant tumors and 1.38×10^{-3} mm²/s in benign tumor. [26] A meta-analysis of 16 studies showed that DWI is able to distinguish between benign and malignant ovarian tumor with 91% sensitivity and 91% specificity. [29,30]

Conclusion

DCE-MRI and DWI have accepted ability to distinguish between benign and malignant ovarian mass. The majority of published data has evaluated functional MRI and cervical cancer with promising results to date. Some limited studies have shown added value of functional MRI in recurrent endometrial and ovarian cancers. Given that both DCE-MRI and DWI-MRI are noninvasive, readily accessible and without ionising radiation, there are advantages in being able use these techniques to further individualise and benefit patient care.

References

1. Kurman RJ, Carcangiu ML, Herrington CS. World Health Organisation classification of tumours of the female reproductive organs. International agency for research on cancer; 2014 Feb 3.
2. Foti PV, Attinà G, Spadola S, Caltabiano R, Farina R, Palmucci S, et al. MR imaging of ovarian masses: classification and differential diagnosis. *Insights Imag.* 2016;7(1):21–41.
3. Mohaghegh P, Rockall AG. Imaging strategy for early ovarian cancer: characterization of adnexal masses with conventional and advanced imaging techniques. *Radiographics.* 2012;32(6):1751–73.
4. Kaku T, Ogawa S, Kawano Y, Ohishi Y, Kobayashi H, Hirakawa T, Nakano H. Histological classification of ovarian cancer. *Medical molecular morphology.* 2003 Mar 1;36(1):9.

5. Valentini AL, Gui B, Miccò M, Mingote MC, De Gaetano AM, Ninivaggi V, Bonomo L. Benign and suspicious ovarian masses—MR imaging criteria for characterization: pictorial review. *Journal of oncology*. 2012 Jan 1;2012.
6. Bernardin L, Dilks P, Liyanage S, Miquel ME, Sahdev A, Rockall A. Effectiveness of semi-quantitative multiphase dynamic contrast-enhanced MRI as a predictor of malignancy in complex adnexal masses: radiological and pathological correlation. *European radiology*. 2012 Apr; 22:880-90.
7. Zhang H, Zhang GF, He ZY, Li ZY, Zhu M, Zhang GX. Evaluation of primary adnexal masses by 3T MRI: categorization with conventional MR imaging and diffusion-weighted imaging. *Journal of ovarian research*. 2012 Dec;5(1):1-8.
8. Sohaib SA, Reznick RH. MR imaging in ovarian cancer. *Cancer Imaging*. 2007;7(Special issue A): S119.
9. Dogheim OY, Hamid AE, Barakat MS, Eid M, El-Sayed SM. Role of novel magnetic resonance imaging sequences in characterization of ovarian masses. *The Egyptian Journal of Radiology and Nuclear Medicine*. 2014 Mar 1;45 (1): 237-51.
10. Priest AN, Gill AB, Kataoka M, McLean MA, Joubert I, Graves MJ, Griffiths JR, Crawford RA, Earl H, Brenton JD, Lomas DJ. Dynamic contrast-enhanced MRI in ovarian cancer: Initial experience at 3 tesla in primary and metastatic disease. *Magnetic Resonance in Medicine: An Official Journal of the International Society for Magnetic Resonance in Medicine*. 2010 Apr;63(4):1044-9.
11. Andrew N, Andrew B, Masako K, McLean MA, Joubert I, Graves MJ, et al. Dynamic contrast enhanced MRI in ovarian cancer: initial experience in 3 Tesla in primary and metastatic disease. *Magn Reson Med* 2010;63: 1044–104.
12. Young R, Scully R. Sex cord stromal, steroid cell and other ovarian tumors. In: Kurman RJ, editor. *Blaustein pathology of the female genital tract*, vol. 35. New York: Springer Verlag; 2002. p. 905–66.
13. Vargas HA, Barrett T, Sala E. MRI of ovarian masses. *Journal of Magnetic Resonance Imaging*. 2013 Feb;37(2): 265-81.
14. Fujii S, Kakite S, Nishihara K, Kanasaki Y, Harada T, Kigawa J, Kaminou T, Ogawa T. Diagnostic accuracy of diffusion-weighted imaging in differentiating benign from malignant ovarian lesions. *Journal of Magnetic Resonance Imaging: An Official Journal of the International Society for Magnetic Resonance in Medicine*. 2008 Nov;28(5):1149-56.
15. Katayama M, Masui T, Kobayashi S, Ito T, Sakahara H, Nozaki A, Kabasawa H. Diffusion-weighted echo planar imaging of ovarian tumors: is it useful to measure apparent diffusion coefficients? *Journal of computer assisted tomography*. 2002 Mar 1;26 (2):250-6.
16. Mohaghegh P, Rockall AG. Imaging strategy for early ovarian cancer: characterization of adnexal masses with conventional and advanced imaging techniques. *Radiographics*. 2012 Oct;32(6):1751-73.
17. Thomassin-Naggara I, Daraï E, Cuenod CA, Fournier L, Toussaint I, Marsault C, Bazot M. Contribution of diffusion-weighted MR imaging for predicting benignity of complex adnexal masses. *European radiology*. 2009 Jun; 19:1544-52.
18. Prado JG, Hernando CG, Delgado DV, Martínez RS, Bhosale P, Sanchez JB, Chiva L. Diffusion-weighted magnetic resonance imaging in peritoneal carcinomatosis from suspected ovarian cancer: diagnostic performance in correlation with surgical findings. *European Journal of Radiology*. 2019 Dec 1; 121:108696.

19. Kaijser J, Bourne T, Valentin L, Sayasneh A, Van Holsbeke C, Vergote I, Testa AC, Franchi D, Van Calster B, Timmerman D. Improving strategies for diagnosing ovarian cancer: a summary of the International Ovarian Tumor Analysis (IOTA) studies. *Ultrasound in obstetrics & gynecology*. 2013 Jan;41(1):9-20.
20. Yamashita Y, Baba T, Baba Y, Nishimura R, Ikeda S, Takahashi M, Ohtake H, Okamura H. Dynamic contrast-enhanced MR imaging of uterine cervical cancer: pharmacokinetic analysis with histopathologic correlation and its importance in predicting the outcome of radiation therapy. *Radiology*. 2000 Sep;216(3):803-9.
21. Punwani S. Contrast enhanced MR imaging of female pelvic cancers: established methods and emerging applications. *European journal of radiology*. 2011 Apr 1;78(1):2-11.
22. Foti PV, Attinà G, Spadola S, Caltabiano R, Farina R, Palmucci S, Zarbo G, Zarbo R, D'Arrigo M, Milone P, Ettore GC. MR imaging of ovarian masses: classification and differential diagnosis. *Insights into imaging*. 2016 Feb; 7:21-41.
23. Iyer VR, Lee SI. MRI, CT, and PET/CT for ovarian cancer detection and adnexal lesion characterization. *American Journal of Roentgenology*. 2010 Feb;194(2):311-21.
24. Li HM, Qiang JW, Ma FH, Zhao SH. The value of dynamic contrast-enhanced MRI in characterizing complex ovarian tumors. *Journal of ovarian research*. 2017 Dec; 10:1-7.
25. Sohaib SA, Reznick RH. MR imaging in ovarian cancer. *Cancer Imaging*. 2007;7(Special issue A):S119.
26. Nasr E, Hamed I, Abbas I, Khalifa NM. Dynamic contrast enhanced MRI in correlation with diffusion weighted (DWI) MR for characterization of ovarian masses. *The Egyptian Journal of Radiology and Nuclear Medicine*. 2014 Sep 1;45(3):975-85.
27. Thomassin-Naggara I, Toussaint I, Perrot N, Rouzier R, Cuenod CA, Bazot M, Daraï E. Characterization of complex adnexal masses: value of adding perfusion-and diffusion-weighted MR imaging to conventional MR imaging. *Radiology*. 2011 Mar; 258(3):793-803.
28. van Nimwegen LW, Mavinkurve-Groothuis AM, de Krijger RR, Hulsker CC, Goverde AJ, Zsiros J, Littooij AS. MR imaging in discriminating between benign and malignant paediatric ovarian masses: a systematic review. *European radiology*. 2020 Feb;30: 116 6-81.
29. Pi S, Cao R, Qiang JW, Guo YH. Utility of DWI with quantitative ADC values in ovarian tumors: a meta-analysis of diagnostic test performance. *Acta Radiologica*. 2018 Nov; 59(11):1386-94.
30. Suarayasa K., Wandira B. A., & P. Study on the Development Needs of the Tadulako General Hospital as Class B State University Hospital for Education (After the Palu City Earthquake). *Journal of Medical Research and Health Sciences*. 2022; 5(8): 2190–2196.