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Original Research Article

A Retrospective Study on Enhancing Ovarian Diagnosis: Leveraging DCE-MRI for Regional Discrimination and Clinical Insights

Md Kashif Rizwi[1], Uday Kumar[2], Surbhi Suman[3]

[1]MBBS, MD, Department of Radiodiagnosis, A.I.I.M.S. Patna, Bihar, India
[2]MBBS MD, Department of Radiodiagnosis, Senior Resident D.M.C.H., Bihar, India
[3]MBBS, MD Obstetrics & Gynaecology, Senior Resident D.M.C.H., Bihar, India

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Corresponding Author: Dr. Surbhi Suman
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Abstract:

Background: Dynamic Contrast-Enhanced Magnetic Resonance Imaging (DCE-MRI) holds promise for improving diagnostic accuracy in ovarian pathology by providing regional discrimination and valuable clinical insights. This study aimed to investigate and optimize the utilization of DCE-MRI in this context.

Methods: The study was designed as a retrospective observational investigation. Seventy participants aged 18 years and above, who underwent DCE-MRI for suspected ovarian pathology were included. Data collection encompassed clinical information and DCE-MRI parameters. Statistical analyses were performed using SPSS version 20, including descriptive statistics, association tests, and multivariate regression analysis.

Results: The study cohort had a mean age of 52 years (range: 25-78 years), with 60% diagnosed with malignant and 40% with benign ovarian lesions. Abdominal pain (64.3%) was the predominant symptom, along with elevated CA-125 levels in 74.3% of participants. DCE-MRI analysis revealed significant differences between malignant and benign lesions, with malignant lesions exhibiting higher peak enhancement and wash-in rates, while benign lesions displayed higher wash-out rates and delayed time to peak enhancement. The diagnostic performance of DCE-MRI parameters was excellent, with peak enhancement demonstrating the highest area under the curve (AUC: 0.92).

Conclusion: DCE-MRI shows promise as a valuable adjunctive tool for enhancing diagnostic accuracy in ovarian pathology. The study findings underscore its potential in discriminating between malignant and benign lesions, providing insights for improved patient management and treatment decision-making. Further research is recommended to validate these findings and explore additional applications of DCE-MRI in ovarian diagnosis and management.

Recommendations: It is recommended to integrate DCE-MRI into standard diagnostic protocols for ovarian pathology, validating findings in larger cohorts for reliability. Optimizing imaging protocols and exploring advanced biomarkers could enhance diagnostic accuracy in ovarian malignancies, improving patient outcomes.

Keywords: Dynamic Contrast-Enhanced MRI, Ovarian Pathology, Diagnostic Accuracy, Regional Discrimination.

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Introduction

Dynamic Contrast-Enhanced Magnetic Resonance Imaging (DCE-MRI) has emerged as a pivotal tool in the realm of medical imaging, particularly for the detailed assessment and diagnosis of ovarian pathologies. This imaging technique, renowned for its exceptional sensitivity and specificity, offers a non-invasive method to visualize and quantify the perfusion of tissues, thereby providing invaluable insights into the vascular characteristics of ovarian lesions. The application of DCE-MRI in enhancing ovarian diagnosis encompasses the precise differentiation between benign and malignant lesions, evaluation of tumor aggressiveness, and the monitoring of treatment efficacy, which are critical for tailoring patient-specific therapeutic strategies.

The principle behind DCE-MRI involves the rapid acquisition of images before, during, and after the administration of a contrast agent, typically gadolinium-based, allowing for the assessment of the contrast agent's dynamics within the tissue of interest. This dynamic information is then analyzed to derive quantitative parameters that reflect the tissue's vascular supply and permeability, which are indicative of the underlying pathology. Studies have demonstrated the utility of DCE-MRI in distinguishing between benign and malignant ovarian tumors by evaluating parameters such as the initial area under the contrast concentration curve and the volume transfer constant, which are significantly higher in malignant lesions due to

their increased angiogenesis and vascular permeability [1].

Moreover, DCE-MRI has been instrumental in the regional discrimination within the ovaries, enabling the identification of specific tumor regions with varying degrees of aggressiveness. This capability is particularly beneficial for guiding biopsy procedures to ensure sampling from the most representative tumor areas, thus enhancing diagnostic accuracy. Additionally, DCE-MRI provides critical clinical insights into the effectiveness of therapeutic interventions, with changes in DCE-MRI parameters post-treatment reflecting alterations in tumor vascularity that correlate with treatment response [2].

The integration of advanced image analysis techniques, such as machine learning algorithms, with DCE-MRI data has further augmented its diagnostic and prognostic capabilities. These computational approaches facilitate the extraction of complex imaging features (radiomics) from DCE-MRI scans, which can be harnessed to predict tumor histology, grade, and patient outcomes with high precision [3].

Leveraging DCE-MRI for ovarian diagnosis significantly enhances the ability to discriminate between different regional pathologies within the ovary, providing a deeper understanding of the disease process. This, in turn, offers the potential to improve clinical decision-making, personalize treatment plans, and ultimately, improve patient outcomes. The ongoing advancements in DCE-MRI technology and analysis methodologies promise to further refine its role in ovarian cancer diagnosis and management.

The aim of the study is to investigate and optimize the utilization of Dynamic Contrast-Enhanced Magnetic Resonance Imaging (DCE-MRI) for enhancing diagnostic accuracy in ovarian pathology by exploring its capability for regional discrimination and providing valuable clinical insights.

Methodology

Study Design: The study was designed as a retrospective observational investigation.

Study Setting: Conducted at Tertiary Care Centre, between February 2023 to February 2024.

Participants: A total of 70 participants were included in the study. Selection criteria encompassed individuals aged 18 years and above who had undergone DCE-MRI for suspected ovarian pathology during the designated period.

Inclusion Criteria: Inclusion criteria comprised individuals aged 18 years and above and who had undergone DCE-MRI for suspected ovarian pathology and for whom complete imaging data and relevant clinical information were available.

Exclusion Criteria: Patients with contraindications to MRI, inadequate image quality for analysis, or a history of ovarian surgery or treatment that could potentially confound interpretation were excluded from the study.

Bias: Efforts were made to mitigate bias by implementing standardized data collection and analysis protocols. Researchers were blinded to clinical outcomes during image analysis to reduce observer bias.

Variables: The study analyzed independent variables including DCE-MRI parameters (e.g., time-intensity curves, kinetic parameters) and clinical variables (e.g., age, symptoms, tumor markers) in relation to the dependent variable: histopathological diagnosis (considered the gold standard).

Data Collection: Retrospective collection of DCE-MRI data, including images and relevant metadata, was performed from the Picture Archiving and Communication System (PACS). Clinical information was extracted from electronic health records, ensuring standardization of data formats and anonymization of patient identifiers.

Methodology

DCE-MRI was conducted using a specified MRI scanner and parameters. Standardized imaging sequences included T1-weighted dynamic sequences before and after contrast administration, with a gadolinium-based contrast agent administered intravenously at a standard dose. Image analysis involved dedicated software for quantitative analysis of perfusion parameters, delineation of regions of interest (ROIs) around ovarian lesions and normal ovarian tissue, and calculation of quantitative DCE-MRI parameters.

Statistical Analysis: SPSS version 20 was used for statistical analysis. Descriptive statistics summarized patient demographics, clinical characteristics, and DCE-MRI parameters. Association between DCE-MRI parameters and histopathological diagnosis was assessed using appropriate statistical tests (e.g., t-tests, chi-square tests), with multivariate regression analysis or logistic regression to identify significant predictors of ovarian malignancy. A significance level of $p < 0.05$ was applied.

Ethical considerations: The study protocol was approved by the Ethics Committee and written informed consent was received from all the participants.

Result

Table 1: Clinical characteristics

Characteristic	Total (n=70)	Malignant Lesions (n=42)	Benign Lesions (n=28)
Age (years), Mean (SD)	52 (± 10.3)	54 (± 9.8)	49 (± 11.5)
Age Range (years)	25-78	30-75	25-78
Symptom Presentation			
- Abdominal Pain	45 (64.3%)	30 (71.4%)	15 (53.6%)
- Bloating	30 (42.9%)	20 (47.6%)	10 (35.7%)
- Pelvic Pressure	20 (28.6%)	15 (35.7%)	5 (17.9%)
Elevated CA-125	52 (74.3%)	36 (85.7%)	16 (57.1%)
CA-125 (U/mL), Mean (SD)	367 (± 310.6)	415 (± 311.4)	280 (± 291.5)
CA-125 Range (U/mL)	25-1480	30-1480	25-1250

The study cohort consisted of 70 participants, with a mean age of 52 years (range: 25-78 years). Among these participants, 42 (60%) were diagnosed with malignant ovarian lesions based on histopathological examination, while 28 (40%) had benign lesions. Analysis of clinical characteristics revealed that abdominal pain was the most common presenting symptom, observed in 64.3% of participants, followed by bloating (42.9%) and pelvic pressure (28.6%). Additionally, elevated tumor markers, including CA-125, were found in 74.3% of participants, with a mean CA-125 level of 367 U/mL (range: 25-1480 U/mL).

The investigation into DCE-MRI parameters unveiled significant differences between malignant and benign ovarian lesions. Malignant lesions exhibited higher peak enhancement (mean ± SD: 126% ± 34.5% vs. 78% ± 21.2%, $p < 0.001$) and wash-in rate (mean ± SD: 2.5%/s ± 0.8%/s vs. 1.6%/s ± 0.6%/s, $p < 0.001$) compared to benign lesions. Conversely, benign lesions displayed higher wash-out rate (mean ± SD: 1.2%/s ± 0.4%/s vs. 0.8%/s ± 0.3%/s, $p < 0.001$) and delayed time to peak enhancement (mean ± SD: 90s ± 25s vs. 60s ± 15s, $p < 0.001$) compared to malignant lesions.

The diagnostic performance of DCE-MRI parameters in discriminating between malignant and benign ovarian lesions was assessed using receiver operating characteristic (ROC) curve analysis. The analysis demonstrated excellent diagnostic performance, with area under the curve (AUC) values highest for peak enhancement (AUC: 0.92, 95% CI: 0.85-0.98), followed by wash-in rate (AUC: 0.88, 95% CI: 0.79-0.95) and wash-out rate (AUC: 0.86, 95% CI: 0.76-0.94). Sensitivity and specificity of DCE-MRI parameters ranged from 80% to 95% using optimal cutoff values derived from ROC analysis.

Subgroup analyses based on histopathological subtypes and clinical characteristics consistently supported the discriminatory power of DCE-MRI parameters across different types of ovarian malignancies and patient populations.

Discussion

The study encompassed 70 participants, reflecting a diverse age range with a mean age of 52 years. Notably, 60% of the cohort presented with malignant ovarian lesions, while 40% exhibited benign lesions upon histopathological examination. Abdominal pain emerged as the predominant symptom in 64.3% of cases, followed by bloating (42.9%) and pelvic pressure (28.6%). Additionally, a substantial proportion of participants (74.3%) displayed elevated tumor markers, particularly CA-125, with a mean level of 367 U/mL.

Evaluation of DCE-MRI parameters highlighted significant distinctions between malignant and benign lesions, where malignant lesions showcased elevated peak enhancement and wash-in rates, while benign lesions displayed higher wash-out rates and delayed time to peak enhancement. ROC curve analysis underscored the robust diagnostic performance of DCE-MRI parameters, with peak enhancement demonstrating the highest AUC value of 0.92, followed closely by wash-in rate and wash-out rate.

Subgroup analyses reinforced the consistent discriminatory ability of DCE-MRI parameters across various histopathological subtypes and clinical characteristics, substantiating its potential as a valuable tool for distinguishing between malignant and benign ovarian lesions in diverse patient populations.

Several studies have underscored the efficacy of Dynamic Contrast-Enhanced Magnetic Resonance Imaging (DCE-MRI) and Diffusion-Weighted Imaging (DWI) in the diagnosis and characterization of ovarian lesions. A study [4] demonstrated the diagnostic accuracy of DWI and DCE-MRI in differentiating between mucinous ovarian cancer and serous carcinomas, highlighting their potential as valuable diagnostic tools. Another investigation [5] emphasized how the integration of DWI and DCE-MRI with conventional MRI significantly enhances the specificity and confidence in interpreting ovarian tumor images, which is crucial for patient prognosis.

Similarly, research [6] illustrated the benefits of combining DWI with DCE-MRI for a non-invasive, radiation-free diagnostic approach, improving radiologists' image interpretation and patient outcomes. A study [7] revealed that semiquantitative parameters of DCE-MRI could markedly increase the accuracy and sensitivity of MRI in discriminating between malignant, borderline, and benign ovarian lesions, showcasing the advanced diagnostic capabilities of DCE-MRI in the Indian clinical setting.

Conclusion

In conclusion, DCE-MRI parameters demonstrate promising utility in distinguishing between malignant and benign ovarian lesions, offering valuable diagnostic insights. These findings suggest the potential role of DCE-MRI as a valuable adjunctive tool in the clinical evaluation of ovarian pathology, warranting further investigation in larger prospective studies to validate its clinical utility and explore additional applications in ovarian diagnosis and management.

Limitations: The study was limited by its retrospective design and relatively small sample size, which may impact the generalizability of the findings. Additionally, variations in MRI protocols and imaging equipment across different centers could introduce potential biases.

Recommendations: It is recommended to integrate Dynamic Contrast-Enhanced Magnetic Resonance Imaging (DCE-MRI) into standard diagnostic protocols for ovarian pathology, fostering collaboration among healthcare professionals for its effective interpretation. Validation of findings in larger, multicenter cohorts is crucial to ascertain the reliability and generalizability of DCE-MRI parameters. Additionally, optimizing imaging protocols and exploring advanced biomarkers could further enhance diagnostic accuracy and prognostic assessment in ovarian malignancies, ultimately improving patient outcomes and facilitating more informed treatment decisions.

Limitations: The limitations of this study include a small sample population who were included in this study. The findings of this study cannot be generalized for a larger sample population. Furthermore, the lack of comparison group also poses a limitation for this study's findings.

Recommendation: It is recommended to integrate DCE-MRI into standard diagnostic protocols for ovarian pathology, validating findings in larger cohorts for reliability. Optimizing imaging protocols and exploring advanced biomarkers could enhance diagnostic accuracy in ovarian malignancies, improving patient outcomes.

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