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Differentiating between benign and malignant ovarian lesions using magnetic resonance imaging assessment: A systematic review and diagnostic accuracy meta-analysis

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ABSTRACT

Background and Aim: Clinical diagnosis of ovarian cancer involves a combination of symptoms, blood tumor marker tests, and MRI images. Accurate diagnosis is essential for developing effective treatment strategies. MRI is commonly used due to its convenience. This study aimed to assess the diagnostic value of preoperative MRI in distinguishing between benign and malignant ovarian lesions before surgery.

Methods: We performed a systematic search of literature in PubMed, Web of Science, and Scopus with relevant keywords. Studies that did not perform MRI or had insufficient data were excluded. Data extraction was performed based on a standardized sheet. Meta analysis was performed with STATA, R, and R-Studio.

Results: The initial search retrieved 14,967 articles from which 3,921 duplicates were removed. Finally, 15 studies were included based on our eligibility criteria. The pooled sensitivity of MRI in detection benign and malignant lesions was 89% (95% CI: 81%-94%, p-value<0.01). The pooled specificity MRI in detection benign and malignant lesions was 94% (95% CI: 90%-97%, p-value<0.01). There was considerable heterogeneity among the included studies. The I2 index indicates a generalized heterogeneity of 61% with heterogeneity of the sensitivity and specificity being 67% and 57%, respectively.

Conclusion: MRI shows high sensitivity, specificity, and diagnostic accuracy in distinguishing between benign and malignant ovarian tumors. Most studies reported sensitivity above 80% and specificity exceeding 90%. Further large-scale, multi-center prospective studies are needed to further evaluate the diagnostic efficacy of MRI in diagnosing ovarian neoplasms.

Keywords: ovarian cancer, neoplasm, lesion, diagnostic accuracy, magnetic resonance imaging, MRI, sensitivity, specificity

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INTRODUCTION

Ovarian cancer poses a significant health concern and ranks among the leading causes of female mortality attributed to reproductive system tumors. Recent reports indicate that ovarian cancer contributes to the deaths of over 200,000 women globally each year. Ovarian cancer is characterized by high heterogeneity and can be classified into epithelial tumors, germ cell tumors, and sex cord-stromal tumors based on pathology [1-3]. Epithelial ovarian cancer accounts for approximately 90% of all cases, making it the most prevalent subtype. Various factors contribute to the risk of developing ovarian cancer, including familial genetic predisposition, lifestyle choices such as exercise and diet, reproductive history including fertility, breastfeeding, and menstruation, as well as factors like body mass index, gynecological conditions, hormone replacement therapy, and psychological influences [4-6].

Ovarian cancer presents a significant challenge due to its aggressive nature and the lack of specific early clinical manifestations or signs, often leading to delayed diagnosis. Studies indicate that only a minority of ovarian cancer cases are identified at an early stage, with the majority, diagnosed at an advanced stage. Patients diagnosed at advanced stages typically face poor prognoses, with survival rates often falling below 25% [7-9]. Benign ovarian tumors may exhibit nonspecific symptoms such as occasional bloating and lower abdominal masses, while malignant tumors tend to grow rapidly and manifest as irregular masses. Systemic symptoms such as fever, weakness, loss of appetite, and weight loss may also occur. Benign lesions can typically be managed with surgery, yielding favorable outcomes. In contrast, malignant lesions often require comprehensive treatment strategies involving surgery and chemotherapy to manage the disease. However, prognosis is generally unfavorable for patients diagnosed with ovarian cancer in the middle to late stages [10-12].

The combination of clinical symptoms, blood tumor marker tests, and Magnetic Resonance Imaging (MRI) scans is often instrumental in diagnosing ovarian cancer, yet distinguishing between benign and malignant tumors remains a challenge. Comparative studies assessing the sensitivity and specificity of routine examinations play a crucial role in this differentiation process [13-15]. Clinical attention must be focused on accurate disease diagnosis and the development of appropriate treatment strategies. MRI is a widely utilized diagnostic tool due to its ease of use and practicality. The aim of this study was to evaluate

the diagnostic value of preoperative MRI in distinguishing between benign and malignant ovarian lesions prior to surgical intervention.

METHODS AND MATERIALS

This systematic review and meta-analysis study was conducted based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guideline 2020 [16].

Search strategy

Two authors performed a systematic search of literature in the following electronic databases: PubMed, Web of Science, and Scopus. No time limitation was defined and all English studies from the beginning until April, 2024 were included. The relevant Medical Subject Heading (MeSH) terms and related keywords were used in combination to build the search strategy; ("magnetic resonance imaging" OR "MRI") AND ("ovarian cancer" OR "ovarian neoplasm" OR "ovarian lesion").

Eligibility criteria

Our eligibility criteria were defined based on the PICO framework: (P) Population: women suspected for ovarian neoplasm. (I) Not Applicable. (C) MRI findings. (O) distinguishing benign and malignant lesions. Those studies that did not perform MRI or did not perform any diagnostic accuracy measures were excluded. Studies that performed other imaging modalities, lacked individual data, or were not in English, were also excluded.

Data extraction and outcome measures

A standardized Excel sheet was prepared for data extraction. Two independent authors performed the data extraction based on the aforementioned data extraction sheet. Disagreement between these two authors, regarding inclusion, exclusion or data extraction, was discussed and resolved by a third author. The data extraction sheet included the following study characteristics: first author's name, year of publication, study design, country, true positive, true negative, false positive, false negative, total number of cases, mean age, and reference of comparison.

Data synthesis and statistical analysis

We used R (R Foundation for Statistical Computing, Vienna, Austria), R-Studio (R-Studio, Inc., Boston, MA), and STATA 17.0 for the statistical analysis and creating the figures. The pooled sensitivity and specificity were calculated based on metadta package in STATA and mada package in R. The sensitivity and specificity were pooled using the hierarchical logistic regression. The Diagnostic Odds Ratio (DOR), Negative Likelihood Ratio (NEGLR), and Positive Likelihood Ratio (POSLR) were calculated and graphed using mada package in R. The 95% confidence interval was also estimated using the binomial distribution. The Forest Plots and Receiver Operating Characteristic (SROC) plots were also created [17-19].

RESULTS

Our initial search retrieved 14,967 articles from PubMed, Scopus, and Web of Science, from which 3,921 duplicates were removed. After screening the title and abstract of 11,046 records, 66 full texts were retrieved, among which 15 studies figure 1 were included based on our eligibility criteria [4, 6, 10, 14, 20-30]. More detail regarding the study characteristics of the included studies is summarised in table 1.

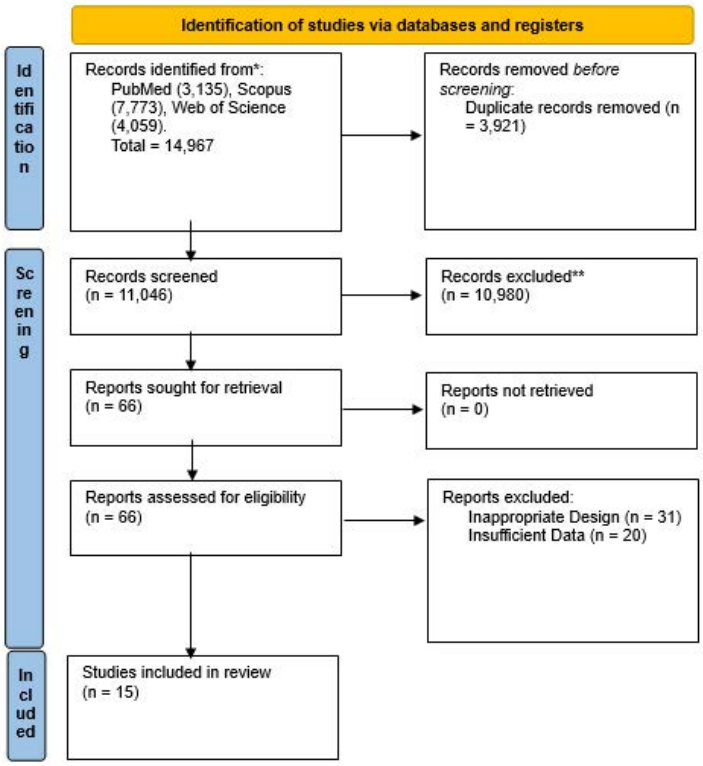

Fig. 1. PRISMA flowchart of the included studies

Tab. 1. The pooled sensitivity, specificity and heterogeneity of the included studies

Heterogeneity	Tau²			I²		
Generalized	1.02			61.36%		
Sensitivity	1.15			67.78%		
Specificity	1			57.30%		
Pooled Statistics						
Study	Year	SEN	95% CI	p	SPC	95% CI	p
Overall	-	89	81-94	<0.01	94	0.90-0.97	<0.01
Bergus et al. [20]	2024	60	32-84	-	94	87-98	-
Fischerova et al. [21]	2022	91	80-98	-	90	68-99	-
Gity et al. [22]	2019	32	13-57	-	96	81-100	-
Hu et al. [23]	2023	89	83-93	-	81	77-85	-
Isono et al. [24]	2023	66	54-76	-	99	99-100	-
Janssen et al. [25]	2021	100	75-100	-	100	78-100	-
Michielsen et al. [26]	2017	97	92-99	-	77	60-90	-
Naggara et al. [29]	2020	93	89-96	-	91	89-93	-
Panico et al. [4]	2023	86	42-100	-	92	64-100	-
Pereira et al. [27]	2018	95	88-99	-	98	92-100	-
Sahin et al. [6]	2021	86	72-95	-	95	92-97	-
Shimada et al. [28]	2018	95	82-99	-	92	88-95	-
Wen et al. (10)	2024	96	88-100	-	100	95-100	-
Yang et al. [14]	2023	82	69-92	-	86	75-94	-
Zhang et al. [30]	2019	90	80-96	-	91	72-99	-

*SEN=sensitivity; SPC=specificity; CI=confidence interval

The pooled sensitivity of MRI in detection benign and malignant lesions was 89% (95% CI: 81% - 94%, p-value<0.01). The pooled specificity MRI in detection benign and malignant lesions was 94% (95% CI: 90%-97%, p-value<0.01). Further detail is available in Figures 2 and 3.

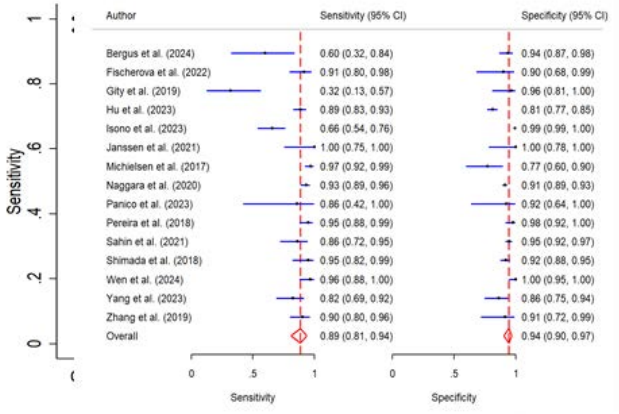

Fig. 2. Pooled sensitivity and specificity of MRI in detecting benign and malignant lesions

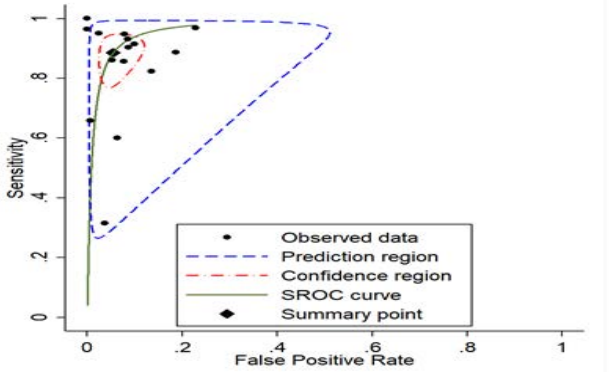

Fig. 3. The Receiver Operating Characteristic (ROC) plot of MRI

There was considerable heterogeneity among the included studies. The I2 index indicates a generalized heterogeneity of 61% with heterogeneity of the sensitivity and specificity being 67% and 57%, respectively. Overall, the diagnostic odds ratios of the included studies were low. The studies by Wen et al. and Janssen et al had the highest DOR respectively (Figure 4).

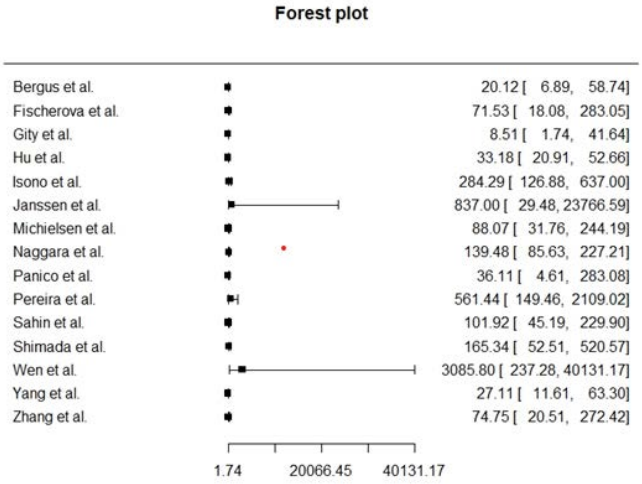

Fig. 4. Diagnostic odds ratio of MRI in detecting benign and malignant lesions

DISCUSSION

Based on the findings of our systematic review and meta-analysis study, MRI had high sensitivity and specificity for distinguishing benign and malignant ovarian lesions from each other. The heterogeneity of the studies was comparably high, however, most studies showed sensitivity more than 80% and specificity more than 90%. The development of ovarian tumors is influenced by both bodily and genetic factors, resulting in benign and malignant tumor formations. Benign tumors typically respond well to treatment and have a favorable prognosis. Conversely, malignant ovarian tumors rank third among gynecological malignancies, following cervical and endometrial cancers [20-32]. Early-stage symptoms are often nonspecific, leading to rapid tumor growth and frequent misdiagnosis or missed diagnosis. Diagnosis usually occurs at advanced stages, complicating treatment and increasing the risk to patients' lives. Therefore, there is a critical need to enhance diagnostic accuracy to guide treatment strategies effectively and ensure timely intervention to improve patient outcomes [21, 33, 34].

Recent advancements in imaging technology have led to the widespread adoption of computed tomography enhanced examination for disease diagnosis. Renowned for its efficiency, accuracy, and three-dimensional capabilities, this imaging modality is now a staple in diagnosing conditions across various bodily systems, including the circulatory, respiratory, and digestive systems. With its ability to provide detailed images while minimizing radiation exposure and layer thickness, the CT is instrumental in both morphological analysis and tumor characterization, distinguishing between benign and malignant tumors [35-37]. Additionally, MRI offers a plethora of parameters and comprehensive image data, enabling clinicians to visualize anatomical structures and detect lesions across different body sections. Recognized for its high soft tissue resolution and diagnostic accuracy, MRI plays a crucial role in diagnosing and differentiating ovarian tumors, facilitating early detection and treatment planning [11, 38, 39].

Benign ovarian tumors typically exhibit well-defined capsules and relatively uniform shapes, whereas malignant tumors demonstrate aggressive growth patterns, irregular shapes, and incomplete capsules [40-42]. Our analysis indicates that MRI offers valuable diagnostic insights for ovarian tumors. MRI exhibits superior sensitivity, specificity, and overall diagnostic accuracy compared. While CT scans provide cross-sectional images, they often struggle to differentiate between endometriotic cysts, the uterine serosal layer, and ovarian tumors [43-45]. In contrast, MRI employs multidirectional and multi-level imaging techniques to capture a wealth of information with high soft tissue resolution. This approach allows for precise delineation of edema, inflammation, and tumor boundaries, offering valuable biochemical and pathological insights [46-49].

MR imaging features associated with malignancy include larger size, thicker walls, presence of septa and/or vegetation within the mass, increased signal intensity on T2-weighted imaging, enhanced contrast enhancement, presence of ascites, peritoneal implants, and bilaterality [50-53]. These findings align with existing literature, which suggests that masses larger than 40 mm, with solid components showing contrast enhancement, or cystic lesions with vegetation>10 mm, wall and septum thickness>0.3 cm, and areas of necrosis are considered suspicious. MR imaging demonstrates relatively good sensitivity in distinguishing malignant from benign masses. However, there is still room for improvement in terms of DOR [54-56].

This meta-analysis has certain limitations inherent to its design. These include potential biases in patient selection, heterogeneity across studies, and variations in study populations. Firstly, the study sample size was relatively small, which may limit the generalizability of the findings. Secondly, the inclusion of both prospective and retrospective studies introduced variability in the data. Lastly, only articles published in English were included, potentially limiting the scope of the analysis. To address these limitations and provide more robust evidence, future studies should focus on conducting multi-center, large-sample investigations to further elucidate the sensitivity and predictive value of MRI in the differential diagnosis of ovarian tumors.

CONCLUSION

Our systematic review and meta-analysis indicate that MRI exhibits high sensitivity, specificity, diagnostic accuracy for differentiating benign and malignant ovarian tumors. Despite the considerable heterogeneity among the studies, the majority reported sensitivity above 80% and specificity exceeding 90%. MRI appears to offer superior capabilities compared to computed tomography, making it a promising non-ionizing imaging modality and potentially a preferable option for patients with ovarian lesions. It should be mentioned that large-scale, multi-center prospective studies are necessary to further assess the comparative diagnostic value of MRI in ovarian neoplasm diagnosis.

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