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Role of computed tomography & magnetic resonance imaging in assessment of peritoneal lesions

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Abstract
Background: The peritoneum is a serosal membrane that can be affected by a variety of pathological conditions, including primary and secondary tumors. Accurate imaging and diagnosis of peritoneal lesions are crucial for tumor staging and treatment planning.
Objectives: This study aims to evaluate the diagnostic performance of CT) Computed Tomography (and MRI (Magnetic Resonance Imaging (in detecting peritoneal lesions and correlating imaging findings with histopathological results.
Patients and Methods: A prospective observational study was conducted over one year at Benha University and Military Hospitals, involving 50 patients with clinical signs suggestive of peritoneal lesions. Patients underwent both CT and MRI, and imaging findings were correlated with histopathological results.
Results: Of the 50 patients, 44% had malignant tumors detected by CT, and 50% by MRI. Sensitivity and specificity for CT were 79.17% and 88.46%, respectively, while MRI showed higher sensitivity (95.83%) and specificity (92.31%). Peritoneal carcinomatosis had an average size of 4.5-5 cm on CT and MRI. MRI demonstrated superior performance with 94% accuracy. Significant differences were found in T1 signal intensity (p=0.02), with MRI showing higher sensitivity for lesion detection.
Conclusion: MRI outperformed CT in detecting peritoneal lesions, with higher sensitivity and specificity. MRI should be considered the primary imaging tool for peritoneal disease, especially in suspected carcinomatosis.

Keywords: Peritoneal lesions, CT imaging, MRI imaging, metastatic tumors, peritoneal pathology

Introduction

The peritoneum is a delicate, semi-transparent membrane of mesodermal origin that envelops the peritoneal cavity and its associated mesenteries, partially or entirely covering the enclosed visceral structures. In males, this serous membrane forms a completely sealed compartment, whereas in females, it maintains an anatomical discontinuity at the ostia of the fallopian tubes, thereby establishing a conduit between the peritoneal cavity and the extraperitoneal pelvic region [1]. Functionally, the peritoneum facilitates smooth visceral motion by providing a low-friction interface and serves as a critical medium for fluid transport. A thin layer of sterile peritoneal fluid not only lubricates intra-abdominal structures but also contributes to innate immune defense mechanisms [2].

From a pathological perspective, peritoneal abnormalities are broadly classified into neoplastic and non-neoplastic conditions, with neoplastic entities further divided into primary and secondary origins. Primary peritoneal tumors arise directly from peritoneal tissues, whereas secondary peritoneal lesions encompass metastatic malignancies, inflammatory and infectious pathologies, as well as a spectrum of miscellaneous proliferative disorders [3]. On a histological level, the peritoneal lining consists of a monolayer of mesothelial cells, demarcated from the underlying sub-mesothelial connective tissue by a distinct basal lamina. The supporting connective tissue framework comprises fibroblast-like elements, collagen and elastic fibers, and an intricate vascular network [4].

Accurate characterization of peritoneal pathology is essential for optimizing tumor staging and guiding therapeutic strategies [5]. Advanced imaging modalities, including ultrasonography (US), multi-detector computed tomography (MDCT), magnetic resonance imaging (MRI), and positron emission tomography-computed tomography (PET-CT), are indispensable in the detection, assessment, and differentiation of peritoneal lesions [6].

This study aims to evaluate the diagnostic performance of CT) Computed Tomography (and MRI (Magnetic Resonance Imaging (in detecting peritoneal lesions and correlating imaging findings with histopathological results.

Patients and Methods

Study design

This study was a prospective observational analysis conducted over a period of one year, at the Radiology Department at Benha University and Military Hospitals involving a total of 50 patients who presented with clinical signs suggestive of peritoneal lesions. The study received approval from the institutional review board, and informed consent was obtained from all patients.

Eligibility criteria

Inclusion criteria: Patients aged between 30 and 85 years. Clinical indications for imaging, including abdominal pain, distension, or suspicion of peritoneal disease based on clinical evaluation. Patients who consented to undergo both CT and MRI scans as part of their diagnostic workup.

Exclusion criteria: Patients with contraindications for MRI, such as the presence of pacemakers, metallic implants, or severe claustrophobia. Patients who had undergone previous abdominal surgeries that could confound imaging results. Incomplete medical records or missing imaging data.

Assessments

Demographic Data: Demographic data was collected from medical records and included age, sex, and comorbidities. Comorbidities recorded included hypertension, diabetes mellitus, and chronic obstructive pulmonary disease (COPD). Other comorbidities, including asthma, were noted.

Radiological Investigations: Both CT and MRI imaging techniques were performed in accordance with standardized protocols

Technique of examination

This study involved the use of high-resolution multidetector CT and 1.5 Tesla MRI to evaluate peritoneal lesions, with all patients undergoing both imaging modalities. CT scans utilized intravenous contrast and were conducted from the diaphragm to the pubic symphysis with axial images reformatted into coronal and sagittal views, while MRI scans included diffusion-weighted imaging with T1- and T2-weighted sequences [7]. The imaging protocols emphasized patient preparation, including fasting for CT and hydration for MRI, to optimize visualization of peritoneal structures. Two blinded observers analyzed the results, correlating imaging findings with pathological and operative outcomes. Lesions were classified into malignant tumors, benign tumors (e.g., adenomas, fibromas), and peritoneal carcinomatosis (PC) based on imaging characteristics such as size, signal intensity, and distribution.

Statistical analysis

A comprehensive statistical analysis was conducted to evaluate and compare the diagnostic efficacy of CT and MRI. The collected data were processed using IBM SPSS Statistics (Version 25.0), with analytical methods tailored according to the data characteristics. The normality of distribution was assessed via the Shapiro-Wilk test. Descriptive statistics included the mean and standard deviation (± SD) for continuous variables, while categorical data were summarized as frequencies and percentages. For inferential statistics, the Student's t-test was employed for comparisons of normally distributed numerical variables, whereas the Mann-Whitney U test was utilized for non-parametric datasets. The Chi-square test was applied to examine associations between categorical variables. Additionally, correlation analysis was performed to determine the relationships between quantitative parameters. Diagnostic accuracy metrics, including sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV), were calculated. Categorical data were analyzed using chi-square tests, while continuous variables were compared through t-tests. Statistical significance was defined at a threshold of $p< 0.05$.

Results

The study included a total of 50 patients, with a mean age of 58 years (SD = 12) and an age range from 30 to 85 years. Of the participants, 28 were male (56%) and 22 were female (44%). Regarding comorbidities, 15 patients had hypertension (30%), 10 had diabetes mellitus (20%), 5 had COPD (10%), and 8 had other conditions such as asthma (16%). Additionally, 12 patients (24%) reported no comorbidities. The most common symptom was abdominal pain, reported by 70% of patients, followed by ascites in 28% and oedema in 18% table 1.

Malignant tumors were detected in 44% of patients via CT and 50% via MRI, with a p-value of 0.45, indicating no significant difference between modalities. Benign tumors were identified in 20% of patients on CT and 16% on MRI, with specific subtypes including adenomas (8% on CT vs. 6% on MRI), fibromas (6% on both), and lipomas (4% on both), all with non-significant p-values. PC was observed in 30% of patients on CT and 28% on MRI (p = 0.30). Other lesions, such as cysts and abscesses, were seen in 16% of patients on CT and 14% on MRI (p = 0.40). MRI signal intensity analysis revealed significant differences, with 50% of patients showing high T1 intensity (p = 0.02), while intermediate and low T1 intensities and T2 intensities showed no statistically significant differences table 2.

PC averaged 4.5-5 cm on CT and MRI, while other malignant tumors were slightly larger (5.2-6 cm) and often located in the right upper quadrant. Benign tumors were smaller, averaging 3.1-4 cm, and primarily in the left lower quadrant. MRI identified normal lymph nodes (0.8 cm), reactive lymphadenopathy (1.5 cm), malignant lymphadenopathy (2.5 cm), and metastatic nodes (3 cm), with distinct locations and imaging features table 3.

In the term of final diagnosis, 24 case (48%) was confirmed to be malignant tumors by final workup (PET CT and histopathological examination). For all malignant tumors, 16 (32%) were Primary tumors and 8 (16%) were Metastatic tumors, CT achieved 84% accuracy, with 79.17% sensitivity and 88.46% specificity. MRI showed higher performance, with 94% accuracy, 95.83% sensitivity, and 92.31% specificity table 4.

Cases

Case 1: A 67-year-old male with metastatic colonic adenocarcinoma and peritoneal deposits on the gastric serosa figure 1.

Case 2: A 55-year-old female with pseudomyxoma peritonei (PMP) figure 2.

Discussion

The peritoneum, a serosal membrane, serves as a potential site for primary tumors but is more commonly affected by secondary pathological processes, with metastatic disease being the predominant neoplastic entity within the peritoneal cavity [8]. The intricate anatomical structure of the peritoneum influences fluid dynamics, subsequently affecting the localization and distribution of pathological processes. Imaging modalities play a pivotal role in assessing peritoneal masses, with metastatic involvement being the primary consideration, particularly in the presence of ascites and peritoneal nodularity, as this directly impacts surgical and therapeutic decision-making [9]. Although primary neoplasms and benign conditions are relatively uncommon, radiologists must be adept at identifying their imaging characteristics to facilitate accurate differential diagnoses [10]. Computed tomography (CT) remains the most frequently employed imaging technique for peritoneal assessment, with its ability to detect varying patterns of peritoneal thickening, aiding in distinguishing between benign and malignant etiologies [11]. Magnetic resonance imaging (MRI), while less commonly available, is gaining prominence as a preferred modality in cases of suspected peritoneal carcinomatosis due to its superior sensitivity, particularly in complex clinical scenarios [12]. Radiologists play a crucial role in the diagnosis, staging, and treatment planning of peritoneal diseases [13]. The work aims to focus the light on the peritoneal lesions by using CT and MRI that detect and delineate the lesion. The imaging diagnosis was confirmed by histopathological analysis before medical or surgical planning.

PC lesions averaged 4.5 cm on CT and 5.0 cm on MRI, while other malignant tumors were slightly larger (5.2 cm on CT and 6.0 cm on MRI). CT exhibited reduced sensitivity for smaller lesions, especially in the small bowel and mesentery, consistent with prior research. MRI, particularly diffusion-weighted imaging, demonstrated superior sensitivity for detecting small lesions in challenging locations [14]. Lymph node evaluation revealed normal nodes averaging 0.8 cm and malignant lymphadenopathy averaging 2.5 cm, emphasizing the importance of imaging in disease staging and treatment planning [15].

The study underscores the clinical challenges of PC, particularly in colorectal and gastric cancers, with cytoreductive surgery (CRS) and hyperthermic intraperitoneal chemotherapy (HIPEC) emerging as potential treatments for selected patients [16]. Further research is needed to enhance management strategies, especially for gastric adenocarcinoma, where HIPEC's efficacy remains under investigation. These findings highlight the complementary roles of CT and MRI in diagnosing and managing peritoneal lesions, with MRI offering advantages in specific clinical contexts [17].

In the present study, the results indicate that both CT and MRI demonstrate effective performance in detecting peritoneal malignancy, but with notable differences in their metrics. For CT, there were 19 true positive (TP) cases and 23 true negative (TN) cases, leading to a sensitivity of 79.17%, meaning that CT accurately identified approximately 79% of the actual positive cases. The specificity for CT was 88.46%, indicating that it correctly identified about 88% of the negative cases. However, the presence of 3 false positives (FP) and 5 false negatives (FN) suggests that while CT is reliable, it may miss some malignancies or incorrectly classify some benign lesions as malignant. The positive predictive value (PPV) of 86.36% indicates that when CT suggests a malignancy, there is an 86% chance that it is correct, while the negative predictive value (NPV) of 82.14% shows that it correctly identifies negatives in about 82% of cases. Overall, CT achieved an accuracy of 84.00%, which is commendable but reflects some limitations in sensitivity.

In contrast, MRI demonstrated superior performance across all metrics, with 23 true positive cases and 24 true negatives. The sensitivity for MRI was significantly higher at 95.83%, suggesting it accurately detected nearly 96% of true malignancies. This high sensitivity is critical in clinical settings where early detection can significantly influence treatment outcomes. The specificity of MRI was also impressive at 92.31%, meaning it correctly identified 92% of negative cases, with only 2 FP and just 1 FN. The PPV for MRI was 92.00%, indicating a strong likelihood that positive results are accurate, while the NPV of 96.00% reflects its high reliability in ruling out malignancy. Ultimately, MRI's overall accuracy of 94.00% underscores its effectiveness as a diagnostic tool for detecting peritoneal malignancy, making it a preferred option in many clinical scenarios.

However, previous literature has demonstrated that both imaging modalities can yield variable sensitivity and specificity depending on the location and size of lesions. For instance, our study corroborates findings from [18]. Which reported pooled sensitivities of 83% for CT and 86% for MRI in detecting PSM. This aligns with our observed sensitivities, highlighting the importance of context-specific evaluation when choosing between imaging modalities.

The current study reinforces the role of both CT and MRI in the evaluation of peritoneal lesions. However, the choice of imaging modality remains complex, influenced by factors such as lesion size and anatomical location. The findings suggest a need for further research to clarify the optimal approach for imaging in PSM assessment, particularly as technology continues to evolve. As both modalities have unique strengths, a combination of imaging techniques may ultimately provide the most comprehensive evaluation for patients being considered for treatments such as CRS-HIPEC.

Overall, the findings of this study contribute to the growing body of literature supporting the use of both CT and MRI in the evaluation of abdominal tumors. While both modalities have their strengths, MRI appears to offer superior sensitivity and specificity, particularly in the context of malignant tumor detection. Future studies should continue to explore the comparative effectiveness of these imaging techniques in larger cohorts to further validate these findings.

This study has some limitations including Potential biases in patient selection, as the study was conducted in a single institution and limitations related to the imaging techniques, including variability in imaging quality and interpretation.

Table 1: Demographic and clinical characteristics of patients, symptoms and associated findings.

Characteristic	Value
Age (Years)	
Mean (SD)	58 (±12.1)
Range	30-85
Sex	
Male	28 (56%)
Female	22 (44%)
Comorbidities	
Hypertension	15 (30%)
Diabetes Mellitus	10 (20%)
COPD	5 (10%)
Other (IHD, Asthma)	8 (16%)
No Comorbidities	12 (24%)
Symptom	**Frequency (%)**
Abdominal Pain	35 (70%)
Nausea	20 (40%)
Vomiting	15 (30%)
Weight Loss	10 (20%)
Generalized oedema	9 (18%)
Ascites	14 (28%)

SD: Standard Deviation, COPD: Chronic Obstructive Pulmonary Disease, IHD: Ischemic Heart Disease

Table 2: Types of peritoneal lesions detected, MRI T1 and T2 signal intensity comparison.

Type of Lesion	CT Findings	MRI Findings	p-value
Malignant Tumors	22 (44%)	25 (50%)	0.45
Peritoneal Carcinomatosis	15 (30%)	14 (28%)	0.30
Other types of malignancy	7 (14%)	11 (22%)	0.11
Benign Tumors	10 (20%)	8 (16%)	0.68
- Adenomas	4 (8%)	3 (6%)	0.74
- Fibromas	3 (6%)	3 (6%)	1.00
- Lipomas	3 (6%)	2 (4%)	0.70
Others (e.g., cysts, abscesses)	8 (16%)	7 (14%)	0.36
Imaging Modality	**T1 Signal Intensity**	**T2 Signal Intensity**	**p-value**
- Low	5 (10%)	3 (6%)	0.45
- Intermediate	20 (40%)	15 (30%)	0.25
- High	25 (50%)	32 (64%)	0.02

CT: Computed Tomography, MRI: Magnetic Resonance Imaging

Table 3: Imaging signs of lesions, associated lymph nodes in patients with peritoneal lesions by MRI.

Imaging Modality	Lesion Type	Size (Mean ± SD, cm)	T1 Signal Intensity	T2 Signal Intensity
CT	Peritoneal Carcinomatosis	4.5 ± 1.8	Variable	Variable
	Other type of malignancy	5.2 ± 2.1	Hyperintense	Hypointense
	Benign Tumors	3.1 ± 1.5	Isointense	Hyperintense
MRI	Peritoneal Carcinomatosis	5.0 ± 2.0	Variable	Hyperintense
	Other type of malignancy	6.0 ± 2.5	Hyperintense	Hyperintense
	Benign Tumors	4.0 ± 1.8	Isointense	Hyperintense
Lymph Node Classification	**Number of Cases**	**Size (Mean ± SD, cm)**	**Main Location**	**Characteristics**
Normal Nodes (no LN involvement)	15 (30%)	0.8 ± 0.2	--	Well-defined, oval shape
Reactive Lymphadenopathy	12 (24%)	1.5 ± 0.5	Mesenteric	Enlarged, hyperplastic
Malignant Lymphadenopathy	18 (36%)	2.5 ± 1.0	Miscellaneous, mainly Retroperitoneal	Irregular borders, necrosis
Metastatic Lymph Nodes	5 (10%)	3.1 ± 1.2	Miscellaneous, mainly Pelvic area	Enlarged, heterogeneous

CT: Computed Tomography, MRI: Magnetic Resonance Imaging, SD: Standard Deviation, LN: Lymph Nodes, cm: centimetre

Table 4: Final diagnosis, type of malignant lesion and incidence of metastasis, validity of CT and MRI for detecting peritoneal malignancy.

	Classification	**Number of Cases**	**Percentage (%)**
Malignant tumors	-Primary tumor	16	32%
	-Metastatic tumor	8	16%
	Total	24	48%
Benign and other types		26	52%
Metric		**CT**	**MRI**
TP		19	23
TN		23	24
FP		3	2
FN		5	1
Sensitivity (%)		79.17%	95.83%
Specificity (%)		88.46%	92.31%
PPV (%)		86.36%	92.00%
NPV (%)		82.14%	96.00%
Accuracy (%)		84.00%	94.00%

TP: True Positive, TN: True Negative, FP: False Positive, FN: False Negative, PPV: Positive Predictive Value, NPV: Negative Predictive Value, CT: Computed Tomography, MRI: Magnetic Resonance Imaging.

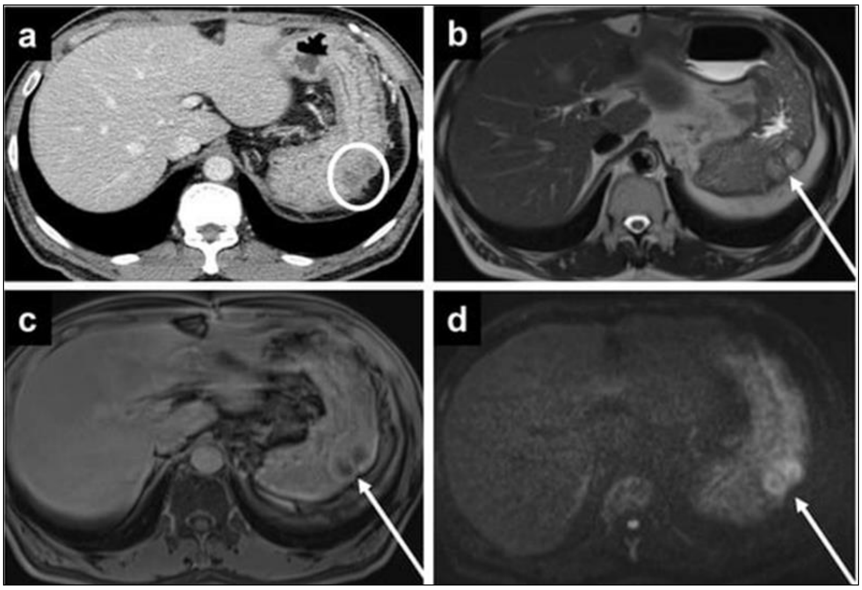

Fig 1: The deposits are not as well seen on (a) CT, as denoted by the white circle and are more apparent on MRI, including (b) T2W, (c) delayed (d) DWI sequences

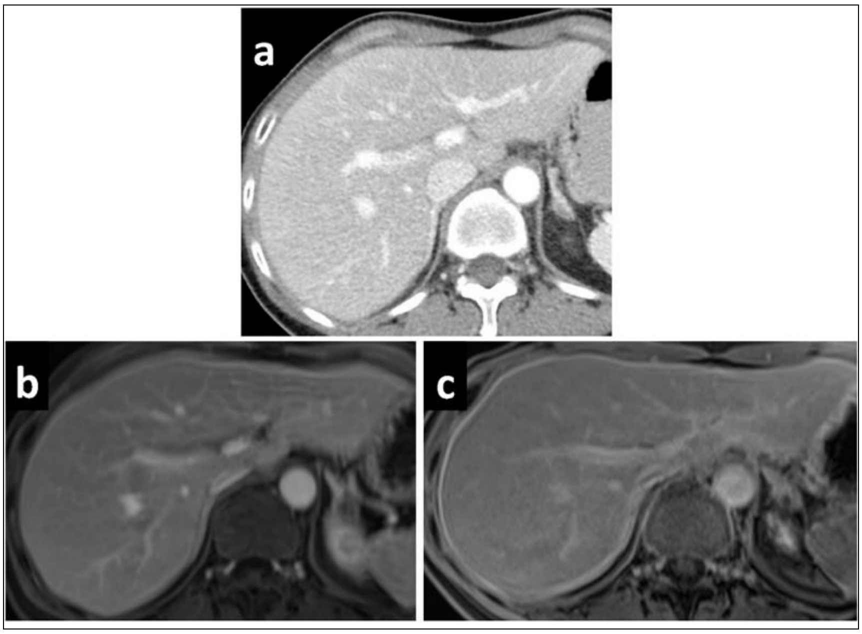

Fig 2: (a) CT reveals no significant abnormality, MRI demonstrates a thin enhancing line surrounding the liver (b) portal venous phase, which becomes more apparent on the (c) delayed phase

Conclusion

The results of this study highlight the vital role of CT and MRI, in the assessment of peritoneal lesions. While both CT and MRI are useful in detecting peritoneal malignancies, MRI demonstrated superior sensitivity and specificity, especially for smaller lesions that may be missed by CT.

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Conflict of interest: None to declare.

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