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Diagnostic performance of contrast-enhanced CT combined with contrast-enhanced MRI for colorectal liver metastases: a case-control study

Luxian Zhang[1] and Luna Bai[1*]

Abstract

Background Colorectal liver metastases (CRLM) are a major determinant of prognosis in colorectal cancer (CRC) patients. Their early and accurate detection is essential for appropriate therapeutic planning and improving survival outcomes.

Purpose To evaluate the diagnostic capabilities of contrast-enhanced computed tomography (CT) and contrast-enhanced magnetic resonance imaging (MRI) in detecting colorectal liver metastases.

Materials and methods We employed a case-control design to compare patients with histologically confirmed liver metastases against a control group without the condition. A total of 85 patients in each group were selected and retrospectively matched based on relevant factors. All subjects underwent both contrast-enhanced CT and MRI. The diagnostic performance of these imaging modalities was assessed by analysing sensitivity, specificity, positive and negative predictive values, and radiologists' diagnostic confidence. Kappa statistics were used to evaluate inter-observer agreement. All MRI scans were performed using a 3-Tesla (3-T) MRI scanner to ensure high-quality imaging and detailed lesion characterization. And all the scans were reviewed by two radiologists.

Results The combination of contrast-enhanced CT and MRI demonstrated a statistically significant improvement in sensitivity (90.6% for MRI alone vs. 96.5% for combined modalities) and specificity (95.3% for MRI alone vs. 98.3% for combined modalities). Positive and negative predictive values were similarly enhanced. Radiologists' diagnostic confidence was higher with combined imaging, achieving a 'very high' confidence level in 78.8% of cases compared with 64.7% for MRI alone. The inter-observer agreement reached 'almost perfect' status with the combined approach.

Conclusion The integration of contrast-enhanced CT with MRI significantly enhanced the diagnostic accuracy for colorectal liver metastases, representing a valuable tool for the preoperative evaluation of patients with CRC.

Clinical trial number Not applicable.

Keywords Colorectal cancer, Liver metastases, Diagnostic imaging, Computed tomography, Magnetic resonance imaging, Contrast-enhanced MRI

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Introduction

Colorectal cancer (CRC) is a significant global health issue and a leading cause of cancer-related mortality [1]. Liver metastasis is common in CRC, impacting prognosis and treatment options. Accurate detection and characterization of liver metastases are crucial for optimal treatment planning, which may include surgical resection, systemic chemotherapy, and targeted therapies [2].

Traditionally, contrast-enhanced computed tomography (CT) has been the primary imaging modality for detecting colorectal liver metastases due to its accessibility and high resolution [3]. However, magnetic resonance imaging (MRI), particularly with liver-specific contrast agents, has gained prominence for its superior contrast resolution, allowing better detection of small or ambiguous lesions [4].

The complexity of hepatic metastases presents challenges in oncologic imaging. While solitary lesions are less common [5], the liver's extensive vascular network facilitates the spread of neoplastic cells from primary malignancies [6]. The portal venous system plays a crucial role in this dissemination, transporting neoplastic emboli from abdominal organs [7].

This unique physiological environment promotes the growth of metastatic cells within hepatic sinusoidal spaces [8]. underscoring the liver's status as a common secondary site for various cancers [9].

Early and accurate detection of liver metastases is essential for prognostic evaluation and therapeutic planning in CRC patients [6]. Surgical intervention can significantly enhance survival rates, highlighting the importance of precise preoperative imaging [5, 10]. Discrepancies between preoperative imaging and intraoperative findings can negatively impact patient care [11, 12].

Despite advancements in imaging technology, individual methods may still be insufficient for accurate staging. Integrating multiple imaging techniques can address these limitations and enhance diagnostic accuracy [5]. A systematic review by Floriani et al. (2010) [13], demonstrated that MRI with gadolinium-based contrast agents exhibits superior sensitivity compared to CT for detecting small hepatic lesions. Moreover, recent studies [14, 15], have shown that combining diffusion-weighted imaging (DWI) with gadoxetic acid-enhanced MRI significantly improves diagnostic performance compared to CT and PET/CT.

While previous studies have evaluated the performance of CT and MRI independently, our study is among the first to systematically assess their combined use in clinical practice. This research aims to leverage the strengths of both modalities, enhancing lesion detectability and diagnostic confidence, particularly in inconclusive cases. Given the evolving landscape of CRC management, this study seeks to compare the diagnostic performance of contrast-enhanced CT and MRI, evaluate the benefits of a multimodal approach, and determine whether it can significantly improve sensitivity, specificity, and diagnostic confidence in assessing hepatic metastatic burden in CRC patients.

Materials and methods

Study design and participants

Our retrospective case-control study involved a review of electronic medical records was performed, including demographic data, imaging reports, and histopathological findings, to identify patients diagnosed with colorectal liver metastases. Histological findings and clinical follow-up were used as reference criteria to confirm diagnoses [16].

The inclusion criteria included patients who underwent contrast-enhanced computed tomography (CT) and contrast-enhanced magnetic resonance imaging (MRI) between January 2021 and June 2023, excluding those with incomplete imaging data or previous liver surgery. Additionally, those with a history of chemotherapy or liver ablation were not excluded. This selection process yielded a cohort of 85 patients with colorectal liver metastases. We used convenience sampling method. Our control group was meticulously chosen from the same population, matching them to the patient cohort based on demographic and clinical characteristics. The mean age of the participants was 62 years, ranging from 35 to 84 years.

We utilized a sophisticated case-control matching algorithm to ensure that the control group was comparable to the patient cohort. This algorithm considered factors such as age, gender, body mass index (BMI), and primary tumor location. Each patient with metastases was paired with a control subject who had undergone similar imaging procedures but showed no signs of liver metastases. It should be noted that the final cohort does not represent consecutive patients, as the selection was based on the availability of complete data and matching criteria. Our study adhered strictly to the ethical guidelines outlined in the Declaration of Helsinki and received approval from the institutional review board (IRB) at the participating center. We obtained written informed consent from all patients for the review and inclusion of their medical records and imaging data.

Sample size Estimation

To determine the required sample size for this study, a standard statistical formula was used to compare the sensitivity of two imaging modalities (CT and MRI). This formula ensures that the number of participants is sufficient to detect a real difference between the two methods.

The formula used is as follows:

$$n = \frac{(Z_{1-\frac{\alpha}{2}} + Z_{1-\beta})\,[p_1(1-p_1) + p_2(1-p_2)]}{(p_1 - p_2)} \times m$$

Power analysis calculations with G*Power software indicate that with p_1 = expected sensitivity for CT (0.50), p_2 = expected sensitivity for MRI (0.70), power = 80%, $p = 0.05$, and matching ratio 1:1, 148 participants (74 per group) would be needed to detect an effect size of 0.40. However, to increase the power of study 85 patients included in each group.

Radiologists' training and standardization

To ensure consistency in the review process, both radiologists received similar training for diagnosis and followed the same calibration method. They reviewed 20 cases to standardize their assessment of liver metastases. Any discrepancies during the study's image review process were resolved through consensus.

Imaging

Patients first undergo a contrast-enhanced CT scan, followed by a contrast-enhanced MRI. In a contrast-enhanced CT scan, an iodine-based contrast agent is used to diagnose diseases by increasing the density contrast between the lesion and surrounding tissues. This contrast agent is not paramagnetic and does not affect tissue relaxation time, so its injection does not interfere with MRI results. In a contrast-enhanced MRI, a gadolinium-based contrast agent is typically used, which helps diagnose diseases by altering tissue relaxation time. Gadolinium has a higher atomic mass than iodine and can significantly affect tissue density differences. As a result, gadolinium injection may influence CT scan results. According to the institution's guidelines, liver and kidney function tests from the past seven days are required before performing a contrast-enhanced CT or MRI. Additionally, CT scanning is performed first, followed by MRI at least one day later. Both CT and MRI scans are completed during the same hospitalization period.

CT technique

Contrast-enhanced CT scans were acquired using a Philips IQon Spectral CT scanner. CT contrast agent was iopromide (Yovex, 300 mg/ml) according to bodyweight, was injected prior to the examination. The CT imaging protocol was standardized using intelligent contrast agent tracking technology with a threshold of 150 HU for arterial phase scanning, with portal and equilibrium phases scanned at 45 s and 120 s after the arterial phase, respectively. CT scans were set to a slice thickness of 3 mm. The parameters for these sequences were adjusted to precisely characterize liver lesions. For CT imaging, protocols were carefully set to achieve optimal image quality for liver lesion detection. The CT scanner was configured with a collimation setting of 64 × 0.625 mm to ensure high-resolution imaging. The contrast agents were injected at a rate of 3.5 mL/s for CT. CT images were reconstructed using a deep-learning-based True Fidelity algorithm to improve diagnostic accuracy. Radiation doses were monitored, with CTDIvol ranging from 10 to 15 mGy and DLP between 300 and 500 mGy·cm, depending on the patient's body habitus [17].

MRI technique

All MRI scans were conducted using a Philips Ingenia 3.0T MR scanner (made in Netherland). For liver imaging, a 16-channel phased-array coil was utilized. The imaging protocol included multiple sequences. A T2-weighted axial sequence with respiratory triggering and Single Shot Turbo Spin Echo technique was applied, with the following parameters: TE = 80 ms, field of view (FOV) 430 × 330 mm, matrix 300 × 206, slice thickness 7 mm, and an acquisition time (TA) of 1 min and 15 s. Additionally, a dual-echo gradient echo (GE) axial sequence was performed under breath-hold conditions, with TR/TE/TE = 142/2.3/4.6 ms, FOV 400 × 327 mm, matrix 308 × 193, slice thickness 5 mm, and a TA of 38 s. A respiratory-triggered diffusion-weighted imaging (DWI) sequence was also included, with parameters TR/TE = 1301/56 ms, FOV 400 × 322 mm, matrix 144 × 94, slice thickness 8 mm, and b-values of 0, 10, 150, 300, and 450, with a TA of 3 min. The Apparent Diffusion Coefficient (ADC) map was generated using b-values of 0, 150, 300, and 450. For contrast-enhanced imaging, an axial T1-weighted fat-saturated GE sequence was performed before and after intravenous administration of 0.1 mmol/kg gadoterate meglumine. The parameters for this sequence were TR/TE = 4/1.95 ms, FOV 375 × 295 mm, matrix 188 × 147, slice thickness 4 mm, and a TA of 20.3 s. This was followed by a coronal T1-weighted fat-saturated GE sequence, with identical TR/TE values, FOV = 375 × 375 mm, matrix 192 × 192, slice thickness 4 mm, and TA of 22 s. Metastatic liver lesions were identified based on their imaging characteristics: hypointense on T1-weighted images, variably hyperintense on T2-weighted images, hyperintense on DWI, and hypointense on the ADC map. Detected metastases were recorded by their size and specific segmental location within the liver [18].

Two board-certified radiologists with extensive experience in abdominal imaging (6 years each) independently reviewed the CT and MRI images. They were blinded to the patients' clinical information and the results of the other imaging modality. They evaluated the presence, size, and location of liver metastases, as well as the image quality and diagnostic confidence for each modality. Two independent radiologists reviewed CT and MRI images independently, ensuring blinding to clinical data.

Table 1 Demographics and clinical characteristics of study participants

Characteristics	Patients with metastases (*n* = 85)	Matched controls (*n* = 85)	*P*-value
Age (years), mean (range)	62 (35–84)	62 (35–84)	-
Gender, n (%)			
- Male	45 (52.9%)	44 (51.8%)	0.88
- Female	40 (47.1%)	41 (48.2%)	0.88
Body Mass Index (kg/m^2), mean ± SD	27.5 ± 4.2	27.3 ± 4.0	0.76
Prior chemotherapy, n (%)	48 (56.5%)	-	-
Primary tumor location, n (%)			
- Right colon	25 (29.4%)	-	-
- Left colon	35 (41.2%)	-	-
- Rectum	25 (29.4%)	-	-

Discordances between reviewers were resolved through a consensus meeting to minimize bias. Images were evaluated using a four-level scoring as 1 = unacceptable image noise (poor), 2 = average image noise affecting the image (moderate), 3 = minimal image noise (good), and 4 = high-denition (HD) image (excellent) [19].

Statistical analysis

SPSS 25 (IBM Corp, Armonk, NY, USA) was used for data analysis due to its comprehensive statistical tools and user-friendly interface. We employed the McNemar test to compare the diagnostic effectiveness of CT and MRI. Sensitivity, specificity, positive predictive value, and negative predictive value were calculated for each imaging modality. Furthermore, we used kappa statistic to quantify the inter-observer agreement regarding the identification and characterization of the liver metastases. The significance level for the results was set at $\alpha = 0.05$. P-values less than 0.05 were considered statistically significant.

Results

The mean age of both patients with metastases and the control group was 62 years. The gender distribution was nearly equal, with slightly more males in the patient group (52.9%) compared to the control group (51.8%). The mean Body Mass Index (BMI) was similar between the two groups, with patients having a slightly higher BMI compared to controls (27.3). A notable difference was that 56.5% of the patients had received prior chemotherapy. The primary tumor locations were distributed across the right colon (29.4%), left colon (41.2%), and rectum (29.4%) (Table 1).

CT scans were rated as excellent in 52.9% of cases, whereas MRI scans had a higher proportion of excellent ratings at 70.6%. 'Good' quality ratings were given to 35.3% of CT scans and 23.5% of MRI scans. Both CT and MRI scans had no instances of "Poor" or "Non-diagnostic" quality ratings (Table 2).

Table 2 Imaging quality assessment by modality

Quality parameter	CT scans, *n* (%)	MRI scans, *n* (%)	*P*-value
Excellent	45 (52.9%)	60 (70.6%)	< 0.01
Good	30 (35.3%)	20 (23.5%)	< 0.01
Satisfactory	10 (11.8%)	5 (5.9%)	0.22
Poor	0 (0%)	0 (0%)	-
Non-diagnostic	0 (0%)	0 (0%)	-

Table 3 Diagnostic performance of imaging modalities

Diagnostic Metric	CT Scans (%)	MRI Scans (%)	*P*-value
Sensitivity	76.5	90.6	< 0.05
Specificity	82.3	95.3	< 0.05
Positive Predictive Value	79.4	92.4	< 0.05
Negative Predictive Value	80.0	94.1	< 0.05

Table 4 Radiologists' diagnostic confidence by imaging modality

Diagnostic Confidence Level	CT Scans, *n* (%)	MRI Scans, *n* (%)	*P*-value
Very High	30 (35.3%)	55 (64.7%)	< 0.01
High	40 (47.1%)	25 (29.4%)	0.03
Moderate	15 (17.6%)	5 (5.9%)	0.11
Low	0 (0%)	0 (0%)	-
Very Low	0 (0%)	0 (0%)	-

Table 5 Inter-Observer agreement in detection of liver metastases

Parameter	Kappa Statistic	Agreement Level	95% CI
CT Scans	0.72	Substantial	0.65–0.79
MRI Scans	0.86	Almost Perfect	0.81–0.91

To assess the diagnostic performance of the combined approach, the sensitivity of contrast-enhanced CT and MRI combined was found to be 96.5%, which was a significant improvement compared to the sensitivity of MRI alone (90.6%) and CT alone (76.5%) for detecting colorectal liver metastases. This combination showed superior results in detecting lesions of all sizes, particularly those smaller than 1 cm. and specificity (95.3% vs. 82.3%). The Positive Predictive Value (PPV) and Negative Predictive Value (NPV) were also higher for MRI scans compared to CT scans (Table 3).

MRI scans were associated with higher levels of diagnostic confidence, with 64.7% of readings rated as "Very High," compared to 35.3% for CT scans. CT scans had a higher percentage of confidence level (47.1% vs. 29.4% for MRI scans) (Table 4).

CT scans showed substantial agreement between the two radiologists, with a kappa statistic of 0.72. MRI scans demonstrated almost perfect agreement between the radiologists, with a kappa statistic of 0.86 (Table 5).

Table 6 demonstrates the distribution of patients detected with metastases. For patients with right colon tumours, CT detected metastases in 25.9% of cases, while MRI detected them in 28.2%. For left colon tumours, CT detected metastases in 35.3% of patients, whereas MRI detected them in 38.8%. For rectal tumours, CT detected metastases in 38.8% of patients, while MRI detected them in 32.9% (Table 6).

MRI scans consistently outperformed CT scans in detecting liver metastases of all sizes. For lesions smaller than 1 cm, CT detected 75 lesions (83.3% detectability) and MRI detected 85 lesions (94.4% detectability). Both modalities achieved 100% detectability for lesions larger than 3 cm (Table 7).

In Fig. 1, an enhanced T1-weighted MRI in the sagittal view vividly illustrates significant wall thickening and lumen stenosis in the sigmoid-rectal region of a 50-year-old female. This is crucial for assessing the extent of local disease and potential involvement of surrounding tissues, providing valuable insights for surgical planning and assessment of tumor invasiveness.

Figure 2 showcases a CT scan in the delayed phase, revealing a relatively low-density lesion in the upper segment of the right anterior lobe of the liver (S8). The axial view offers critical information about the lesion's characteristics and its interaction with adjacent hepatic structures, essential for surgery or targeted therapy planning.

In Fig. 3, a CT scan during the portal phase displays two low-density lesions in the upper right anterior liver lobe (S8), captured in the coronary view. This image helps in the differential diagnosis, suggesting the vascular nature of the lesions and their potential as metastatic sites, which is key in staging and management.

Figure 4 presents a T1-weighted MRI during the portal phase, illustrating a lesion in the upper segment of the right anterior lobe (S8) with low signal intensity and uneven internal signals. The axial view provides essential details about the lesion's heterogeneity, aiding in the assessment of tumor composition and potential response to treatment.

Figure 5 shows an MRI image during the portal phase depicting two lesions with slightly lower signal intensities in the right anterior upper lobe of the liver (S8). The lesions exhibit uneven internal signals, seen in the coronary view, which can indicate the complexity and aggressiveness of the metastatic disease, influencing therapeutic decisions.

Table 6 Patient distribution by primary tumor location and detected metastases

Primary Tumor Location	Patients with Metastases Detected by CT ($n=85$)	Patients with Metastases Detected by MRI ($n=85$)	*P*-value
Right colon	22 (25.9%)	24 (28.2%)	0.78
Left colon	30 (35.3%)	33 (38.8%)	0.62
Rectum	33 (38.8%)	28 (32.9%)	0.54

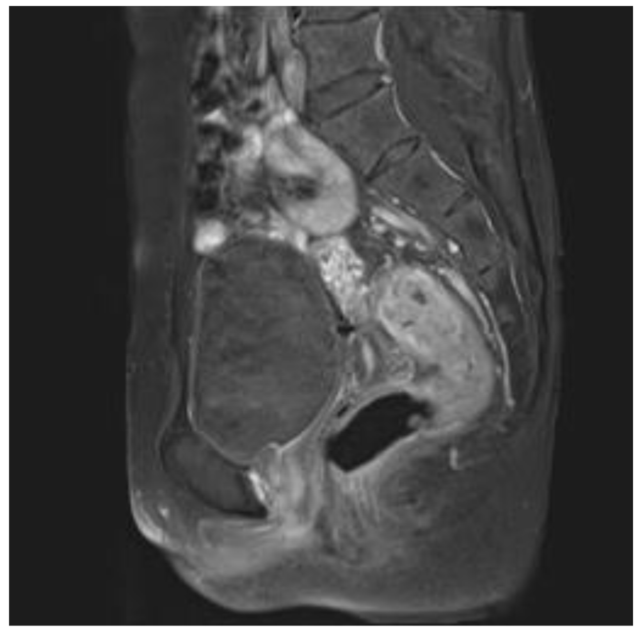

Fig. 1 Enhanced T1-weighted MRI (sagittal view) showing sigmoid-rectal wall thickening and lumen stenosis in a 50-year-old female

Fig. 2 CT image during the delayed phase showing a low-density lesion in the upper segment of the right anterior lobe (S8) of the liver (axial view)

Table 7 Comparison of lesion detectability between CT and MRI

Lesion Size Category	Lesions Detected by CT (*n*)	Lesions Detected by MRI (*n*)	Total Lesions (*n*)	CT Detectability (%)	MRI Detectability (%)	*P*-value
< 1 cm	45	65	70	64.3	92.9	< 0.01
1–3 cm	75	85	90	83.3	94.4	< 0.05
> 3 cm	30	30	30	100	100	-

Fig. 3 CT image during the portal phase showing two low-density lesions in the upper right anterior liver lobe (S8) (coronary view)

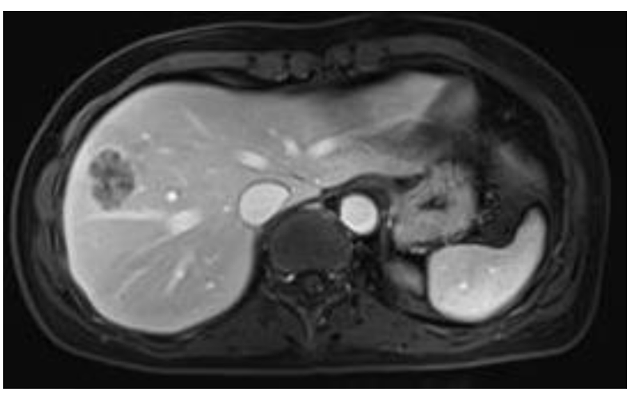

Fig. 4 T1-weighted MRI during the portal phase depicting a lesion with low signal intensity and uneven internal signal in the upper segment of the right anterior lobe (S8) (axial view)

Fig. 5 MRI image during the portal phase showing two lesions with slightly lower signal intensities in the right anterior upper lobe of the liver (S8), featuring uneven internal signals (coronary view)

Discussion

MRI demonstrated statistical significance in sensitivity, specificity, positive predictive value, and negative predictive value compared to CT. MRI scans exhibited higher image quality, enhancing radiologist confidence in diagnostic accuracy. With 'Almost Perfect' inter-observer agreement levels, MRI surpassed the 'Substantial' agreement observed with CT scans, outperforming CT in detecting lesions of all sizes, particularly those smaller than 1 cm.

These findings are pivotal for advancing oncologic imaging and patient care. MRI's higher sensitivity in identifying metastatic lesions enables earlier detection, potentially improving the effectiveness of subsequent interventions and reducing unnecessary tests, anxiety, and healthcare costs for patients. Additionally, the study's outcomes could inform clinical guidelines, advocating for MRI as the preferred imaging modality for evaluating colorectal cancer metastases to the liver, ultimately improving survival rates and quality of life through more personalized treatments.

Our results align with previous studies highlighting MRI's superior performance over CT in detecting colorectal liver metastases. Floriani et al. (2010) [13] conducted a systematic review and meta-analysis of various imaging modalities for diagnosing liver metastases from colorectal cancer. Their findings indicated that MRI, particularly when enhanced with contrast agents, consistently outperforms CT, especially in the detection of small lesions, which is crucial for early diagnosis and treatment planning. In line with this, Vilgrain et al. (2016) [14] emphasized the value of diffusion-weighted imaging (DWI) and gadoxetic acid-enhanced MRI in improving detection rates of small lesions compared to conventional techniques. Their meta-analysis confirmed DWI MRI's superior sensitivity and specificity, especially for liver metastases smaller than 1 cm.

In a study by Qiu et al. [20] 66 colorectal cancer patients underwent CT and MRI scans analyzed independently by two radiologists using different protocols, including CE-CT alone and CE-CT with NE-MRI or CE-MRI. Their results indicated that the CE-CT and NE-MRI protocol significantly improved hepatic lesion detection rates, particularly for lesions under 10 mm. Similarly, Ozaki et al. [21] examined 87 patients using gadoxetic acid-enhanced MRI and CE-CT, evaluating abbreviated MRI protocols against standard MRI and combined approaches. Their findings showed that abbreviated MRI protocols achieved diagnostic accuracy comparable to standard MRI.

Sivesgaard et al. [22] studied 76 colorectal cancer patients undergoing FDG-PET/CT, CE-CT, and MRI before treatment. They utilized a dual-reader system for image interpretation, assessing sensitivity, specificity, and AUC_ROC values. Cantwell et al. [23] analyzed imaging data from 33 patients using low-radiation NE-PET/CT, CE-PET/CT, and liver MRI. They found that while MRI's performance was comparable to CE-PET/CT, it excelled in lesion characterization based on superior AUC values.

While CE-CT is effective for detailed visualization of the liver's vascular structure, it may struggle with small nodules and differentiating benign from malignant lesions due to variations in hepatic blood flow [24]. This presents diagnostic challenges in accurately classifying conditions like hepatocellular carcinoma (HCC) [25, 26]. Both CT and MRI can occasionally struggle to characterize indeterminate hepatic lesions, highlighting the need for enhanced imaging strategies and additional diagnostic criteria to improve overall diagnostic accuracy [26].

Studies indicate that MRI, using liver-specific contrast agents, performs better than CT in detecting liver metastases. However, in clinical practice, due to the higher costs and limited availability of MRI, CT is often used as the primary staging tool, while MRI is reserved for cases where CT results are inconclusive or for more precise surgical planning. Regarding the combined use of CT and MRI, studies show that this approach can enhance diagnostic accuracy. However, due to additional costs and increased time requirements, it is generally recommended for complex cases or situations where the results of a single modality are insufficient [27–29].

Our findings suggest that integrating contrast-enhanced CT with MRI offers a significant improvement in diagnostic accuracy compared to using either modality alone. Unlike prior studies that focused on a single imaging technique, our research highlights the clinical advantage of a multimodal approach, which can be particularly beneficial for patients with borderline respectable liver metastases. Also our results indicate that combining contrast-enhanced CT and MRI improves diagnostic accuracy, this approach should be tailored to clinical needs. In cases where a single modality provides conclusive findings, additional imaging may not be necessary. However, in patients with inconclusive findings or those being considered for curative-intent surgery, complementary imaging can be highly valuable.

Limitations

This study has several limitations. Notably, the absence of spectral reconstructions at lower energy levels, such as 50 keV, may affect diagnostic accuracy, as previous research (Beeres et al., 2015) indicates that this energy level enhances image contrast. The retrospective design introduces selection bias due to reliance on histological confirmation of liver metastases, limiting generalizability [30]. Conducting the study in a single institution restricts applicability, as differences in imaging equipment, radiologist expertise, and patient demographics may vary. Although the sample size showed statistical significance, it may not capture the full variability in metastatic CRC presentations, and variations in contrast administration and prior treatments could affect lesion visibility. The lack of longitudinal follow-up prevents assessment of the prognostic value of combined imaging results. Another limitations of this study is its retrospective design and the use of convenience sampling, which may lead to selection bias and reduce the generalizability of the results. In future studies, the use of a prospective design and random sampling methods could mitigate these limitations and enhance the external validity of the findings. Additionally, the present study has primarily focused on diagnostic accuracy, and the impact of combined imaging on clinical outcomes such as treatment decisions, patient survival, and recurrence rates has not been examined. Future studies should investigate the effects of these methods on therapeutic management and patient prognosis. Also, this study used gadotrate meglumine instead of liver-specific contrast agents such as gadoxetic acid, which may reduce diagnostic sensitivity in detecting small metastases.

Conclusion

The combined use of CT and MRI significantly enhanced diagnostic accuracy compared to either modality used independently, indicating a higher proficiency in identifying true positives and true negatives. The combined approach was particularly effective in detecting small lesions, which are often challenging to visualize and characterize. Radiologists reported higher confidence levels when interpreting the combined imaging results, which is crucial for clinical decision-making. The elevated confidence levels likely reflect the complementary nature of the information provided by CT and MRI. The inter-observer agreement reached a high level with the combined imaging, suggesting consistency in diagnostic interpretation among different radiologists. The study's findings suggest that the concurrent use of CT and MRI may offer a more accurate and reliable means of evaluating colorectal liver metastases, potentially leading to improved clinical outcomes such as more precise staging, better treatment planning, and more informed prognostic assessments. The results advocate for the adoption of combined imaging protocols in the preoperative assessment of patients with colorectal cancer, supporting a more strategic and targeted approach to the management of liver metastases. previous studies have shown that MRI generally outperforms CT in detecting small hepatic lesions, but CT remains the initial imaging modality due to its accessibility and cost-effectiveness. Therefore, we suggest that a combined approach be reserved for patients with inconclusive results or those being evaluated for curative-intent interventions.

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Author contributions
L.Z. and L.B. were major contributors to conceptualization and writing the manuscript. Both authors collected the patient data and followed up the patients. Both authors read and approved the final manuscript.

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None.

Data availability
The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
The Ethics Committee of Zhongshan Hospital Xiamen University, Xiamen City, Fujian Province, China approved the study. All participants were provided with a written informed consent form, clearly stating that their participation in the study was voluntary and that they had the right to withdraw at any time without facing any consequences. The participants guardians were provided with detailed explanations about the confidentiality of their information. Written informed consent was obtained from all participants. All methods were carried out in accordance with relevant guidelines and regulations.

Consent for publication
None.

Competing interests
The authors declare no competing interests.

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