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Accuracy of endoscopic ultrasonography plus abdominal CT versus plus MRI in differentiating benign from malignant pancreatic space-occupying lesions

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► ***Original article***

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ABSTRACT

Background: Pancreatic space-occupying lesions (PSOLs) represent common yet complex digestive disorders. Current studies focus on endoscopic ultrasonography (EUS) combined with single imaging modality, but direct comparisons between these combination strategies are limited. This study assesses the comparative diagnostic effectiveness of EUS with abdominal computed tomography (CT) versus EUS paired with magnetic resonance imaging (MRI) in distinguishing benign from malignant pancreatic space-occupying lesions (PSOLs), to inform refined clinical diagnostic approaches. ***Materials and Methods:*** This prospective study enrolled 158 patients with suspected PSOLs from May 2024 to March 2025. Participants were assigned to either EUS+CT (n=84) or EUS+MRI (n=74) group. The diagnostic accuracy of these combinatorial strategies for PSOLs was appraised against the gold standard (pathological section results or puncture biopsy findings). Additionally, subgroup analyses were conducted on subgroups featuring small lesions (≤2 cm in diameter) or mucinous cystic neoplasms (MCNs). ***Results:*** The gold standard confirmed 127 patients to have PSOLs. For EUS + CT, the diagnostic sensitivity, specificity, and accuracy for PSOLs were 72.31%, 63.16%, and 70.24%, respectively, with a Kappa (κ) value of 0.646 (P<0.05). In comparison, EUS combined with MRI showed superior performance with 82.26% sensitivity, 83.33% specificity, and 82.43% accuracy (κ=0.802, P<0.05). Subgroup analysis further indicated that the EUS-MRI strategy was significantly more effective in detecting small lesions and MCNs than the EUS-CT approach (P<0.05). ***Conclusion:*** EUS paired with MRI may provide more accurate diagnoses than EUS plus CT in most cases, particularly for small lesions and MCNs, while EUS-CT retains value in specific scenarios.

INTRODUCTION

Pancreatic space-occupying lesions (PSOLs) represent common yet complex digestive disorders, encompassing a wide spectrum of pathologies from benign cysts to invasive malignancies [1]. Given the substantial variations in treatment strategies and prognoses across this spectrum, accurately distinguishing benign from malignant lesions early holds great significance for clinical decision-making [2]. In recent years, endoscopic ultrasonography (EUS) has gained widespread application, thanks to its superior resolution and capacity for close-range observation of pancreatic lesions. Yet, advancing research and clinical practice have shown that EUS has limited sensitivity when it comes to detecting tiny lesions and is highly influenced by the operator's experience [3, 4]. Moreover, its reliance on soft tissue resolution introduces challenges in the differentiation of certain hypervascular or mucinous tumors [5].

Consequently, advancing early PSOL detection methods that are accurate, rapid, and safe is a critical yet challenging research priority [6]. Recently, researchers have tried to enhance EUS by combining it with other imaging techniques. For instance, contrast-enhanced abdominal computerized tomography (CT) utilizes multi-phase scanning to effectively visualize a lesion's vascularity, its invasion into adjacent vessels, and the presence of distant metastases [7]. On the other hand, magnetic resonance imaging (MRI), leveraging multi-parameter imaging and functional imaging technologies, can provide a broader tissue characterization [8]. Currently, combining EUS with either CT or MRI is a common practice for a comprehensive assessment [9, 10]. Nevertheless, most existing studies concentrate on the improvement of a single technology, such as the application of high-field MRI or new EUS probes.

There is still a lack of systematic comparisons between these two combined diagnostic protocols. Furthermore, the optimal strategy for refining the differential diagnosis of specific pancreatic tumor types (e.g., mucinous cystic neoplasms, MCNs) and small lesions (≤2 cm) using combined methodologies remains undefined. Therefore, this study compared

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the diagnostic effectiveness of EUS combined with either abdominal CT or 3.0T MRI in patients with PSOLs. The findings are expected to provide important evidence-based medical support for the preoperative diagnosis of PSOLs. If EUS plus MRI demonstrates significantly superior sensitivity, specificity, and diagnostic accuracy compared to EUS plus CT, it may promote the preferential use of MRI-based combination strategies in clinical practice, and vice versa. Such improvements could reduce the risks of missed diagnoses and misdiagnoses, optimize treatment planning, and guide individualized therapy through accurate staging.

MATERIALS AND METHODS

Study subjects

This study included a cohort of patients defined by suspected PSOLs, who were admitted to our institution between May 2024 and March 2025 for retrospective analysis. Patients were consecutively assigned to EUS+CT or EUS+MRI groups based on admission date (odd vs. even dates) to ensure comparable baseline characteristics. The sample size required for the study was calculated using G-Power software. The parameter settings were as follows: effect size w=0.3 (based on pre-experiments), α=0.05, power=0.8, and df=5. The minimum sample size calculated was 143. Taking a 10% dropout rate into account, 158 patients were ultimately enrolled. This study has obtained approval from the Zhoukou Central Hospital of Henan University of Traditional Chinese Medicine's Ethics Committee (No.20240925001,2024-09-25), with informed consent acquired from all participants.

Selection criteria

Inclusion criteria: (1) Age ≥18 years with full medical records. (2) Suspected PSOLs (diameter ≥1 cm) on CT/MRI, requiring benign/malignant differentiation. (3) Lesions clearly visible on EUS and pathologically examined. (4) No previous treatment for PSOLs before study participation. Exclusion criteria: (1) Severe cardiac, pulmonary, hepatic, or renal insufficiency. (2) Metastatic pancreatic tumors. (3) Pregnancy or lactation.

Examination protocols

EUS: The Olympus EU-ME2 endoscopic ultrasonography system (Japan) equipped with a 12 MHz linear probe was utilized. After an 8-hour fast, patients received oral lidocaine mucilage 10 minutes pre-examination to anesthetize the pharynx. While positioned laterally on the left side, the endoscope was introduced orally and advanced to the descending duodenum. The probe frequency (5-12 MHz) was then adjusted to perform multi-sectional scanning of the pancreas. Assessment emphasized the mass's position, size, boundaries, and internal echotexture (e.g., cystic, solid, or complex, noting calcifications or septations), as well as its Doppler flow characteristics and relationship to key vascular structures like the splenic vein and superior mesenteric artery/vein (SMA/SMV).

CT: A Siemens SOMATOM Definition Flash dual-source CT scanner (Germany) was employed. Following a 4-hour fast, patients were scanned from the diaphragmatic dome to the inferior renal pole, with a 5 mm slice thickness and 1 mm reconstructions. For contrast-enhanced scanning, non-ionic iohexol (350 mgI/mL) was injected through an antecubital vein at 3.5 mL/s using a high-pressure injector, with the total injection volume ranging from 80 to 100 mL. Images were acquired in the arterial (25-30 s), portal venous (60-65 s), and delayed (120-180 s) phases post-contrast injection. Scanning parameters comprised 120 kV tube voltage, automatically regulated tube current (reference 150 mAs), and a 512×512 matrix. Image post-processing involved multi-planar and curved planar reconstructions, focusing on characterizing the lesion's enhancement pattern, margins, surrounding vascular infiltration, and any distant metastases.

MRI: Imaging was performed on a Siemens Magnetom Prisma 3.0T MRI scanner (Germany). Patients were fasted for 4 hours and administered oral ferric ammonium citrate solution (20 g/1000 mL) with warm water 30 minutes before scanning to suppress peristalsis. The scanning parameters were set as follows: For T1-weighted imaging (T1WI), the repetition time (TR) was 180 ms, the echo time (TE) was 2.3 ms, the slice thickness was 3 mm, and the slice gap was 0 mm; for T2WI with fat suppression, the TR was 8000 ms, the TE was 85 ms, the slice thickness was 3 mm, and the slice gap was 0 mm; for diffusion-weighted imaging (DWI), the b-values were set at 50 s/mm^2 and 800 s/mm^2, the TR was 3000 ms, the TE was 68 ms, the slice thickness was 3 mm, and the slice gap was 0 mm. During contrast-enhanced scanning, gadoxetic acid disodium (Zhengdatianqing Pharmaceutical Group Co., LTD., China, 0.1 mmol/kg) was injected at 2 mL/s, with a total injection volume of 10-15 mL. The scanning phases were the same as those for CT. Post-processing was performed to measure the apparent diffusion coefficient (ADC) (with a region of interest [ROI] placed in the viable lesion parenchyma, avoiding necrosis), score the DWI signal (1: low, 2: iso-intense, 3: high), and analyze DCE-MRI parameters like time to peak and enhancement rate.

Malignancy determination criteria

EUS: Malignancy was diagnosed based on the presence of at least one of the following morphological characteristics: hypoechoic or heterogeneous echotexture compared to surrounding normal pancreas; poorly defined or irregular borders

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with signs of infiltration; internal features such as irregular calcifications, necrotic areas, or septations; heightened or chaotic internal vascularity; or involvement of neighboring vessels (e.g., splenic vein, SMA, SMV) through compression, encasement, or invasion (figure 1).

CT: A lesion was deemed malignant if it exhibited an arterial phase CT value increase of ≥20 HU compared to the non-contrast scan, exceeding the attenuation of adjacent normal pancreatic tissue, along with a decline of ≥15 HU in the portal venous or delayed phase. Furthermore, at least one morphological characteristic had to be present: ill-defined margins with infiltration into peripancreatic fat; dilation of the main pancreatic duct or its branches; calcifications; or vascular invasion (figure 2).

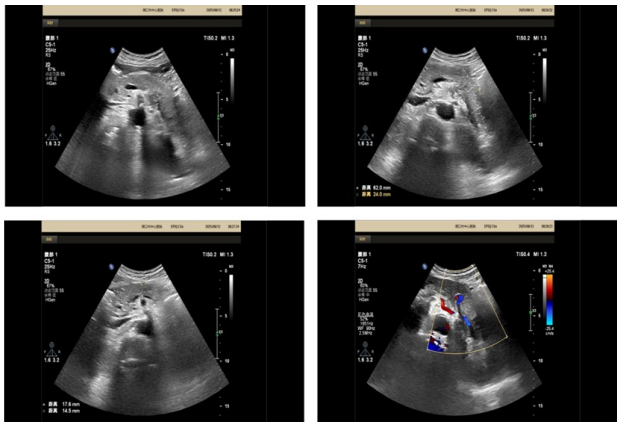


Figure 1. EUS findings in a given patient. Male, 78 years old. EUS image showing a hypoechoic mass (arrow) with irregular borders in the pancreatic head, suggestive of malignancy.

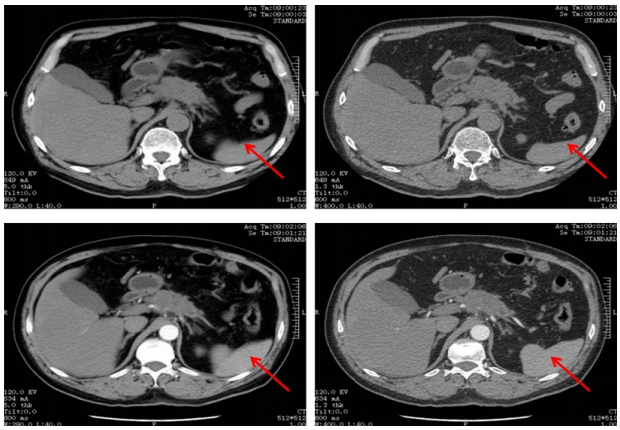


Figure 2. CT findings in a given patient. Male, 62 years old. Contrast-enhanced CT demonstrating a hypodense lesion (arrow) with peripheral enhancement in the pancreatic body.

MRI: MRI findings indicative of malignancy were: T1WI hypointensity, T2WI and DWI hyperintensity, ADC value lower than $<1.2\times10^{3}$mm2/s, obvious arterial enhancement, and rapid washout (enhancement decrease exceeding 50%) in later phases (figure 3).

Outcome measures

With the pathological findings (from surgical resection specimens or puncture needle biopsy) serving as the "gold standard", the diagnostic performance indicators of the two groups were assessed. For the combined method, a lesion was defined as malignant if both tests agreed [11].

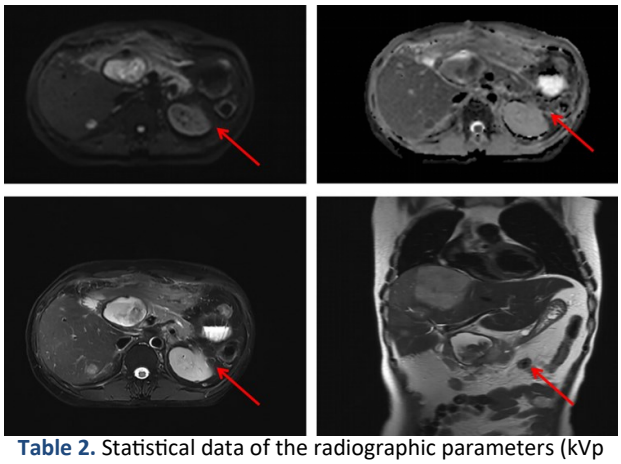


Table 2. Statistical data of the radiographic parameters (kVp and mAs values) and patient anthropometric data for selected X-ray examinations.

Quality control

All examinations were performed by qualified radiologists, and equipment was calibrated regularly. Two senior radiologists, unaware of the pathological results, independently reviewed all imaging exams. In case of any disagreement between them, a third chief physician was consulted to make the final decision. Pathological diagnoses were reviewed by two senior pancreatic pathology experts. EUS-guided fine-needle aspiration (EUS-FNA) specimens were reviewed by two pathologists in a double-blind manner. Inter-observer agreement between the two radiologists was excellent (Kappa=0.859, P<0.001).

Data statistics

Data were imported into the SPSS 30.0 software (IBM, USA) for statistical analysis. Count data, represented by [n (%)], were comparatively analyzed with the chi-square test or Fisher's exact test. Diagnostic performance assessment employed the Kappa (κ) test. A κ value nearer to 1 denotes stronger agreement with the gold standard. Statistical significance was defined as a p-value of less than 0.05.

RESULTS

Baseline data of study subjects and pathological examination

Among the 158 included patients suspected of having PSOLs, there were 85 males and 73 females, presenting a relatively balanced gender distribution. The age ranged from 54 to 72 years, which suggests that the middle-aged and elderly population is a high-risk group for this disease. Abdominal pain was the primary symptom, some patients were accompanied

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by jaundice, suggesting biliary tract involvement and necessitating imaging evaluation for potential obstruction. Hemoglobin levels remained within the normal range, indicating no severe anemia in the overall patient population. Through pathological examination or puncture biopsy, 127 patients were confirmed to have PSOLs (table 1).

Table 1. Clinical data of the study subjects

Projects	n	Percentage
Age	62.81±5.35	
Sex		
male	85	53.80%
female	73	46.20%
Clinical symptoms		
abdominal pain	121	76.58%
no symptoms	37	23.42%
Accompanied by jaundice		
yes	14	8.86%
no	144	91.14%
Combined with diabetes mellitus		
yes	52	32.91%
no	106	67.09%
Location of the lesion		
head	82	51.90%
body and tail	76	48.10%
Hemoglobin (g/L)	125.90±18.78	

Diagnostic performance of EUS combined with CT for PSOLs

Among 84 patients examined using EUS and CT, 54 were identified with PSOLs. Pathological biopsy, however, confirmed PSOLs in 65 cases. After calculation, the diagnostic sensitivity, specificity, and accuracy of EUS combined with CT for PSOLs were 72.31% (47/65), 63.16% (12/19), and 70.24% (59/84), respectively. The agreement between the combined modality and pathology, as measured by the κ statistic, was 0.646 (P<0.05) (table 2).

Table 2. Diagnostic performance of EUS combined with CT for PSOLs.

Methods		Pathological biopsy			κ	P
		(+)	(-)	Total		
EUS Combined with CT	(+)	47	7	54	0.646	0.021
	(-)	18	12	30		
	Total	65	19			

Note: endoscopic ultrasonography (EUS), computed tomography (CT).

Diagnostic performance of EUS combined with MRI for PSOLs

EUS plus MRI examinations were performed on the other 74 patients, yielding 53 cases of PSOLs, compared to 62 confirmed by pathological biopsy. This combined modality demonstrated 82.26% (51/62) sensitivity, 83.33% (10/12) specificity, and 82.43% (61/74) accuracy for detecting PSOLs, with strong pathological agreement (κ=0.802, P<0.05) that is superior to EUS plus CT (table 3).

Comparison of detection performance of EUS-CT vs. EUS-MRI for small lesions

A subgroup analysis of 62 patients with small lesions (≤2 cm) was performed. The detection rate was 46.43% (13 of 28 patients) for those examined with EUS plus CT, whereas it was 73.53% (25 of 34 patients) for those who underwent EUS plus MRI. The inter-group comparison revealed a statistically significant higher detection rate for the EUS-MRI combination (P<0.05) (table 4).

Table 3. Diagnostic performance of EUS combined with MRI for PSOLs.

Methods		Pathological biopsy			κ	P
		(+)	(-)	Total		
EUS Combined with MRI	(+)	51	2	53	0.802	<0.001
	(-)	11	10	21		
	Total	62	12			

Note: endoscopic ultrasonography (EUS), magnetic resonance imaging (MRI).

Table 4. Comparison of diagnostic accuracy between EUS-CT and EUS-MRI for small lesions (≤2 cm).

Methods	n	Detected	Not detected
EUS Combined with CT	28	13 (46.43)	15 (53.57)
EUS Combined with MRI	34	25 (73.53)	9 (26.47)
c^2		4.753	
P		0.029	
95%CI		0.101-0.958	

Note: endoscopic ultrasonography (EUS), computed tomography (CT), magnetic resonance imaging (MRI).

Comparison of detection performance of EUS combined with either CT or MRI for MCNs

In the subsequent subgroup analysis of 38 MCN patients, EUS combined with MRI demonstrated a higher detection rate than EUS plus CT. EUS-CT correctly identified 7 of 17 cases (41.18%), which was significantly higher than the 16 of 21 cases (76.19%) detected by EUS-MRI (P<0.05) (table 5).

Table 5. Comparison of diagnostic accuracy between EUS-CT and EUS-MRI for MCN.

Methods	n	Detected	Not detected
EUS Combined with CT	17	7 (41.18)	10 (58.82)
EUS Combined with MRI	21	16 (76.19)	5 (23.81)
c^2		4.821	
P		0.028	
95%CI		0.051-0.882	

Note: endoscopic ultrasonography (EUS), computed tomography (CT), magnetic resonance imaging (MRI).

DISCUSSION

This study aimed to compare the diagnostic performance of EUS combined with CT versus MRI for PSOLs. The results demonstrate the superior diagnostic performance of the EUS-MRI combination than EUS plus CT, as well as its superiority in the detection of small lesions (diameter ≤2 cm) and MCNs. These findings provide objective guidance for the early clinical diagnosis of PSOLs in the future.

It is hypothesized that the superior diagnostic performance of EUS plus MRI is attributed to the integration of three technical elements: (1) Multi-parametric MRI accurately identifies lesion properties. Through the T2-weighted fat-suppressed sequence, MRI can clearly distinguish between cystic, solid, and cystic-solid structures. Meanwhile, DWI

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measures restricted water diffusion to reflect cellular density [12, 13]. In contrast, CT relies on iodine contrast enhancement to assess vascularity and tissue involvement but has lower soft tissue contrast, leading to potential underdiagnosis of MCNs in cystic or isodense cases [14]. This observation corroborates earlier research [15]. (2) The complementary role between puncture biopsy and MRI. As is well known, the main advantage of a puncture biopsy lies in its ability to perform puncture under direct visualization. However, it is restricted by the operator's experience and lesion location [16]. CT guidance, limited by poor soft tissue resolution, often relies on secondary signs such as vascular invasion to determine puncture sites [17]. In comparison, MRI, with its multi-planar reconstruction capability and high-resolution T2-weighted imaging, enables real-time guidance of the puncture trajectory, helping to avoid blood vessels and pancreatic ducts and thereby reducing complication risks [18]. Research has indicated superior diagnostic accuracy with MRI-guided biopsy over CT-guided methods in early breast cancer detection [19], corroborating our view. EUS-MRI further optimizes needle placement with the help of MRI anatomical information, potentially lowering the number of ineffective punctures and improving the identification of malignant lesions. (3) Technical limitations impact puncture strategies. CT involves radiation exposure and potential allergic reactions to iodine-based contrast agents, restricting its repeated use. In contrast, MRI offers advantages in longitudinal monitoring owing to its non-invasive nature and multi-sequence compatibility [20]. It should be noted that EUS results are operator-dependent and may be subjective, while MRI's standardized sequences (e.g., T1WI, DWI) help reduce operator-related subjective errors.

Furthermore, while CT excels at assessing main pancreatic duct dilation (≥3 mm), calcifications, and distant metastases, its sensitivity is limited for small lesions (≤2 cm). With its high soft tissue resolution, MRI can clearly display the boundaries and internal structures of lesions ≤2 cm, thus improving the detection rate of such small lesions. Therefore, we recommend EUS combined with MRI as the preferred diagnostic protocol for PSOLs in future clinical practice. Moreover, since MRI is radiation-free and does not require nephrotoxic contrast agents, it is suitable for patients with renal insufficiency or allergic diathesis. Nonetheless, EUS-CT remains a valuable supplementary technique in specific scenarios: in the emergent assessment of biliary obstruction and suspected vascular invasion; in institutions wherein high-field MRI resources are limited; and for clinical cases necessitating a rapid evaluation of both lesion perfusion and distant metastases. In addition, despite the superior accuracy of EUS+MRI, EUS+CT maintains advantages in rapid examination time (5-10 min vs 30-45 min for MRI), lower cost, and wider availability, making it valuable in emergency settings.

This study still has several limitations. To begin with, the 158 included patients were from a single medical center, potentially introducing selection bias. Although groups were balanced in major baseline characteristics, unmeasured confounding factors might exist due to the non-randomized design. Additionally, retrospective analysis makes it difficult to completely avoid pathological sampling errors. To mitigate this, future prospective studies could incorporate core-needle biopsy with imaging fusion to improve sampling accuracy. Furthermore, while statistical significance was observed in subgroup analyses for small lesions (n=62) and MCNs (n=38), these groups were relatively small, necessitating validation with larger samples. Another limitation involves the minor differences in scanning parameters (e.g., slice thickness and contrast dose) between CT and MRI, which could impact the comparability of results. In the future, more in-depth and comprehensive studies should be carried out to address the above limitations, so as to provide more reliable references and guidance for clinical practice.

CONCLUSION

EUS plus MRI outperforms EUS plus CT in distinguishing benign from malignant PSOLs, particularly in identifying tiny lesions and MCNs. Its multi-parameter imaging technology makes up for the shortcomings of traditional imaging methods and can provide a more accurate basis for clinical decision-making. Future multi-center, prospective studies are required to further verify its universality.

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***Authors' contribution*:** R.Y., conceived and designed the project, and wrote the paper. J.G. and L.Y., generated the data. Z.W. and S.L., analyzed the data. Y.S., modified the manuscript. All authors gave final approval of the version to be published, and agree to be accountable for all aspects of the work.

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