Pancreatic Cysts: Comprehensive Radiological Evaluation and Diagnostic Strategy

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Abstract

Background:

Pancreatic cystic lesions are frequently encountered in abdominal imaging, presenting a broad range of diagnostic and management challenges. With the increasing use of cross-sectional imaging techniques, especially CT and MRI, incidental detection of pancreatic cysts has become common. These cysts may be benign, premalignant, or malignant, requiring precise radiological evaluation for appropriate clinical decision-making.

Purpose:

To provide a comprehensive review of radiological modalities used in the evaluation of pancreatic cysts, including their diagnostic accuracy, characteristic imaging features, and roles in risk stratification. The article also discusses guideline-based recommendations for follow-up and management.

Methods:

A literature-based synthesis of comparative studies and guideline documents was performed, examining the diagnostic performance of CT, MRI, MRCP, and EUS (with FNA) in identifying key features such as mural nodules, septations, ductal communication, and malignant stigmata.

Results:

MRI with MRCP demonstrated the highest sensitivity for ductal evaluation and internal cyst structure. CT was useful for detecting calcifications and local invasion. EUS-FNA provided additional diagnostic information via fluid analysis and cytology. Combining MRI and EUS yielded the highest overall diagnostic accuracy (>90%).

Conclusion:

Radiology plays a pivotal role in the management of pancreatic cysts. A structured approach utilizing MRI/MRCP as the primary modality, complemented by CT and EUS when indicated, ensures accurate diagnosis and optimized patient outcomes. Multidisciplinary

collaboration and adherence to international guidelines are essential in tailoring patient-specific management strategies.

Keywords: pancreatic cysts, MRI, CT, EUS, radiology, MRCP, cystic neoplasm, imaging, diagnosis, Fukuoka criteria, IPMN, mucinous cyst, pancreatic cancer.

Introduction

Pancreatic cystic lesions constitute an increasingly common diagnostic finding in clinical radiology, largely due to the widespread and routine application of high-resolution abdominal imaging techniques. In many instances, these lesions are discovered incidentally during imaging performed for unrelated reasons, such as abdominal pain, trauma, or oncologic staging. The growing recognition of pancreatic cysts has led to considerable clinical and academic interest, not only because of their diagnostic complexity but also due to the potentially serious implications for patient management, especially when lesions harbor premalignant or malignant potential.

These cysts encompass a wide histopathologic spectrum—from inflammatory pseudocysts associated with pancreatitis to neoplastic lesions such as serous cystadenomas (typically benign), mucinous cystic neoplasms (MCNs), and intraductal papillary mucinous neoplasms (IPMNs), the latter two being associated with varying degrees of malignancy risk. Importantly, the clinical behavior of cystic pancreatic lesions is highly variable. Some may remain stable for years without intervention, while others demonstrate features of progression such as increasing size, thickened walls, mural nodules, and main duct dilation—hallmarks that raise concern for malignancy. Therefore, timely and accurate radiological characterization is critical to ensure appropriate follow-up or intervention.

Radiologists play a central role in the multidisciplinary care team by identifying key imaging features that help stratify patients into risk categories. CT, MRI (especially with MRCP sequences), and endoscopic ultrasound (EUS) are the primary tools used in this setting. CT remains widely available and effective for initial detection and anatomical localization, whereas MRI provides superior contrast resolution and excels at depicting the cyst's internal architecture and ductal communication. MRCP sequences, in particular, allow for non-invasive evaluation of the main pancreatic duct and its branches. EUS adds a valuable dimension of fine-detail resolution and allows for real-time fluid aspiration and cytological assessment. Collectively, these tools facilitate a highly nuanced, non-invasive approach to diagnosis.

Given the evolving landscape of pancreatic imaging and its growing clinical significance, this article presents a comprehensive review of the radiological evaluation of pancreatic cysts. The

goals are: (1) to describe the imaging characteristics of major cyst types; (2) to compare the diagnostic performance of various modalities; and (3) to provide guidance based on the latest international recommendations, including the Fukuoka, AGA, and European guidelines.

Materials and Methods

This study is based on a comprehensive review of current evidence, including original research articles, meta-analyses, consensus statements, and clinical guidelines relevant to the radiologic evaluation of pancreatic cysts. Sources were selected from PubMed, Embase, Scopus, and professional society publications including the American Gastroenterological Association (AGA), the International Association of Pancreatology (IAP), and the European Study Group on Cystic Tumours of the Pancreas.

The review included imaging-based studies published between 2010 and 2024, encompassing both retrospective and prospective analyses. Included studies compared the diagnostic accuracy of CT, MRI, MRCP, and EUS, and assessed their ability to characterize cyst morphology, ductal anatomy, and malignancy risk. Special attention was given to studies with pathology-confirmed outcomes and those incorporating cyst fluid analysis through EUS-FNA.

Radiological features assessed included: cyst size, shape (unilocular, multilocular), wall thickness, internal septations, mural nodules, calcifications, and the relationship to the pancreatic ductal system. The presence of high-risk stigmata (e.g., enhancing mural nodules, main duct dilation >10 mm) or “worrisome features” (e.g., cysts >3 cm, thickened cyst walls, lymphadenopathy) were documented in accordance with the Fukuoka and AGA criteria.

Data were extracted and qualitatively synthesized, and where possible, metrics such as sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) were reported to compare modalities and support diagnostic recommendations.

Results

Analysis of published evidence confirms that **MRI with MRCP sequences** demonstrates the highest sensitivity (90–95%) for identifying communication between cysts and the pancreatic duct system—an essential feature for distinguishing IPMNs from other cyst types. MRI also excels at detecting internal septations and small mural nodules that are often missed by CT. Moreover,

the non-ionizing nature of MRI makes it especially suitable for follow-up imaging in younger patients or those requiring long-term surveillance.

Computed tomography (CT), while less sensitive in depicting internal structures, remains invaluable for its ability to detect calcifications, assess for solid components, and evaluate adjacent organ involvement in suspected malignancy. Its widespread availability and rapid acquisition times also make CT a practical choice in emergency settings and for initial characterization of large or symptomatic lesions.

Endoscopic ultrasound (EUS), especially when combined with **fine-needle aspiration (FNA)**, provides unmatched resolution for cyst wall evaluation. EUS-FNA allows for biochemical (e.g., CEA, amylase), cytological, and molecular analysis of cyst fluid. Elevated CEA levels (>192 ng/mL) strongly suggest a mucinous cyst, while detection of **KRAS**, **GNAS**, or **TP53** mutations further supports neoplastic or malignant transformation. However, EUS is operator-dependent and more invasive, limiting its use to selected cases with indeterminate or high-risk features on cross-sectional imaging.

Table 1. Comparative Evaluation of Imaging Modalities in Pancreatic Cyst Assessment

Imaging Modality	Strengths	Limitations	Diagnostic Role
CT	Excellent spatial resolution; fast acquisition; good for calcifications and solid components	Radiation exposure; limited soft tissue contrast; ductal communication poorly visualized	First-line tool for detection, anatomy, and staging
MRI/MRCP	Superior soft tissue contrast; non-invasive ductal mapping; detailed internal architecture	Limited availability; contraindicated in some patients	Preferred modality for characterization and surveillance
EUS	High-resolution wall assessment; allows FNA and fluid analysis	Operator-dependent; invasive; limited availability	Best for mural nodules, cytology, and biochemical analysis

Imaging Modality	Strengths	Limitations	Diagnostic Role
EUS-FNA	Biochemical and molecular analysis (CEA, KRAS, etc.)	Invasive; risk of complications; sample-dependent results	Differentiates mucinous vs. non-mucinous cysts
PET-CT	Detects metabolic activity of malignancy	Expensive; low specificity for cysts	Rarely used; adjunct in cancer suspicion

Collectively, studies show that combining **MRI/MRCP with EUS-FNA** provides the most comprehensive assessment, with a reported diagnostic accuracy of over 90% in distinguishing mucinous from non-mucinous lesions and in guiding surgical referral.

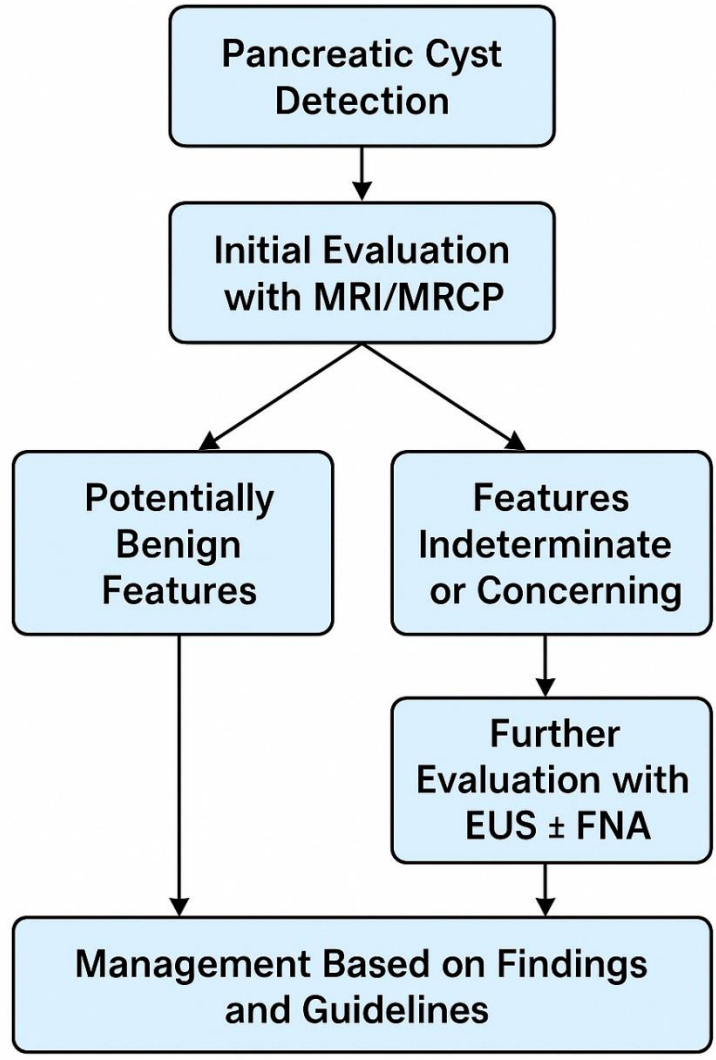
Discussion

The growing prevalence of pancreatic cysts presents both an opportunity and a challenge for modern radiology. While most cysts are asymptomatic and benign, a significant proportion require vigilant follow-up due to their premalignant or malignant potential. Radiologists must therefore act not only as diagnosticians but as clinical consultants, interpreting subtle imaging findings in the context of risk models and clinical algorithms.

The **Fukuoka guidelines** categorize pancreatic cysts into low-risk, intermediate-risk (worrisome features), and high-risk (malignancy-associated stigmata) groups, using imaging as a primary classification tool. Similarly, the **AGA guidelines** prioritize cyst size and the presence of high-risk imaging features in determining follow-up intervals and the need for surgical consultation. **European guidelines** add further granularity by stratifying risk based on genetic and molecular markers when available.

Despite these tools, challenges remain. Small cysts (<2 cm) without high-risk features are often followed conservatively, but data on their long-term progression remain limited. Conversely, cysts >3 cm or those with mural nodules warrant aggressive surveillance or resection due to the higher likelihood of malignancy. Decisions are further complicated in elderly or comorbid patients, where the risks of surgery must be balanced against the potential for malignant transformation.

Thus, a tailored, multidisciplinary approach is essential. Radiologists, gastroenterologists, surgeons, and pathologists must collaborate to determine the most appropriate course of action, leveraging imaging data as the foundation for decision-making.



Diagnostic Approach to Pancreatic Cysts

Conclusion

Pancreatic cysts represent a broad and diagnostically challenging group of lesions, with radiology serving as the primary gateway for their detection, characterization, and clinical triage. Among imaging modalities, **MRI with MRCP** provides superior non-invasive assessment of internal cystic features and ductal relationships. **CT** complements this by offering anatomical detail and identifying calcifications or solid components, while **EUS with FNA** adds invaluable biological insight into cyst behavior.

The integration of imaging findings with clinical and molecular data—supported by evidence-based guidelines—enables accurate risk stratification and guides appropriate surveillance or intervention. In the future, advancements in AI-assisted imaging interpretation, radiogenomics, and real-time molecular diagnostics may further refine this process.

Ultimately, radiologists must remain at the forefront of pancreatic cyst evaluation, applying a structured, informed, and collaborative approach to optimize patient outcomes and prevent progression to pancreatic cancer.

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