Review

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Review

Role of Endoscopic Ultrasound in Pancreatic Metastases: A Comprehensive Review

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Abstract

Metastases to the pancreas (PM), although rare, have been increasingly identified in recent years, especially among high-volume pancreatic centers. They are often asymptomatic and incidentally detected during follow-up examinations, even several years after the treatment of the primary tumor. In this scenario, endoscopic ultrasound (EUS) has emerged as a crucial diagnostic tool for PM, being capable of providing a detailed morphological characterization and safe and effective tissue acquisition for cytohistological examination. The aim of our study was to extensively review the current evidence concerning the role of EUS in the diagnosis of PM, specifically focusing on their morphological features, contrast-enhancement patterns, and tissue acquisition techniques.

Keywords: pancreatic metastases; EUS; EUS-TA; CH-EUS

1. Introduction

Metastases to the pancreas (PM) are relatively uncommon conditions, representing approximately 2–5% of all pancreatic malignancies in surgical and oncologic series, and up to 15% among autopsy studies [1–3]. Given PM commonly mimic primary pancreatic ductal adenocarcinoma (PDAC) in clinical presentation and cross-sectional imaging, a definitive diagnosis is imperative, as management and prognosis differ substantially [4–6]. Since its advent [7–9], endoscopic ultrasound (EUS) has gradually emerged as the cornerstone for the characterization of solid pancreatic lesions, being capable of providing unmatched spatial resolution for pancreatic parenchyma and enabling simultaneous tissue acquisition for cyto-histological diagnosis [10,11].

EUS-guided tissue acquisition (EUS-TA), including fine-needle aspiration (FNA) and fine-needle biopsy (FNB), is essential for the definitive cytohistological diagnosis of PM. Indeed, EUS-TA has been shown to be associated with high diagnostic accuracy rates and negligible adverse events rates for solid pancreatic lesions, including PM [12–18].

In recent years, contrast-enhanced EUS (CH-EUS) has further refined lesion characterization by accurately visualizing microvascular perfusion patterns [19]. Anyway, although CH-EUS enhances diagnostic confidence, tissue confirmation remains mandatory, as contrast patterns may overlap with neuroendocrine tumors and atypical PDAC [20,21].

Accurate diagnosis of PM is crucial, having a direct impact on their subsequent management. For instance, patients with isolated metastases may benefit from surgical resection with long-term

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survival, while the recognition of disseminated disease prevents unnecessary surgery and guides systemic therapy [22–24].

Given the increasing detection of PM in the era of long-term cancer survivorship and the key role played by EUS in this scenario, a comprehensive understanding of EUS morphology, CH-EUS patterns, and tissue-acquisition strategies is essential. Our narrative review aimed to summarize and discuss the current evidence regarding the role of EUS in diagnosing PM, specifically focusing on their morphological features, CH-EUS patterns, tissue acquisition techniques, and their clinical implications.

2. Literature Search

We performed a comprehensive literature search in the PubMed/MEDLINE, Google Scholar and Embase databases up to September 2025 in order to identify relevant studies investigating the role of EUS in the diagnosis of PM.

The search included combinations of Medical Subject Headings (MeSH) and free-text terms related to pancreas, metastases, EUS, and tissue acquisition techniques.

The medical search strategy used the terms “pancreas,” “pancreatic,” “metastases,” “metastatic,” “secondary tumor,” “solid lesions”, “endoscopic ultrasound,” “endoscopic ultrasonography,” “EUS,” “endosonography,” “fine-needle aspiration,” “fine-needle biopsy,” “FNA,” “FNB,” “contrast-enhanced endoscopic ultrasound,” and “CH-EUS” in various combinations, using the Boolean operators AND, OR, and NOT. The search was limited to English-language human studies. Additional relevant articles were carefully identified by manual screening of the reference lists of retrieved publications and pertinent reviews. Meeting abstracts, individual case reports, case series (<5 cases), review articles, position papers, editorials, commentaries, and book chapters were excluded from our review.

3. Role of Endoscopic Ultrasound in Pancreatic Metastases

A total of 26 studies were included in the final analysis [4,5,10,12–16,20,22,25–40]. All were retrospective in nature. Three were case series [10,32,36], sixteen were single-center studies [4,5,13–15,20,25,27–31,33,35,37,38], and seven were multicenter studies [12,16,22,26,34,39,40]. The main characteristics of the included studies are summarized in Table 1 and Table 2.

Table 1. Characteristics and demographics of the included studies.

Reference	Study design	Country	Study type	Enrollment period	Patients, n	Mean age (range), years	Sex male, %
Palazzo et al. *[10]*	Retrospective	France	Monocentric	1989-1993	7	57 (38-77)	42.9%
Fritscher-Ravens et al. *[4]*	Retrospective	Germany	Monocentric	-	12	61 (34-78)	33.3%
Bechade et al. *[35]*	Retrospective	France	Monocentric	1999-2002	11	65.5 (56-82)	72.7%
Mesa et al. *[5]*	Retrospective	USA	Monocentric	2000-2002	11	-	-
Moussa et al.*[22]*	Retrospective	France	Multicentric	1990-2000	22	61 (35-76)	45.5%

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DeWitt et al.*[12]*	Retrospective	USA	Multicentric	1998-2004	24	60 (33-83)	62.5%
Layfield et al. *[40]*	Retrospective	USA	Multicentric	2002-2010	17	60.9 (15-80)	88.2%
Hijoka et al. *[31]*	Retrospective	Japan	Monocentric	1997-2010	28	59.8 (20-72)	46.4%
Pan et al. *[32]*	Retrospective	USA	Monocentric	2010-2012	6	66.5 (59-73)	83.3%
Ardengh et al. *[39]*	Retrospective	Brazil	Multicentric	1997-2010	37	60.3 (26–84)	70.3%
El Hajj et al. *[25]*	Retrospective	USA	Monocentric	1998-2010	49	63 (30-83)	46.9%
Atiq et al. *[30]*	Retrospective	USA	Monocentric	2005-2009	23	63	43.5%
Fusaroli et al.*[37]*	Retrospective	Italy	Monocentric	2008-2011	11	66 (42- 82)	27.3%
Waters et al. *[26]*	Retrospective	USA	Multicentric	2002-2012	66	63 (40-89)	57.6%
Smith et al. *[13]*	Retrospective	USA	Monocentric	2000-2014	22	71 (59-83)	59.1%
Alomari et al. *[38]*	Retrospective	USA	Monocentric	2005-2012	31	66 (49-86)	61.3%
Raymond et al. *[28]*	Retrospective	USA	Monocentric	2000-2014	16	(43-84)	68.8%
Sekulic et al. *[27]*	Retrospective	USA	Monocentric	2006-2016	25	64 (53-71) (median, IQR)	52%
Hou et al. *[29]*	Retrospective	USA	Monocentric	2008-2016	30	61.2 (25-82)	60%
Betes et al. *[14]*	Retrospective	Spain	Monocentric	2004-2016	44	58 ± 11.7	63.6%
Ioakim et al. *[36]*	Retrospective	Greece	Monocentric	2013-2018	7	66.9 (56-76)	71.4%
Abdallah et al. *[33]*	Retrospective	USA	Monocentric	2011-2017	8	68.38 ± 10.56	50%
Teodorescu et al. *[20]*	Retrospective	Romania	Monocentric	2012-2020	20	62 (56–66)(median, IQR)	50%
Spadaccini et al. *[16]*	Retrospective	Italy	Multicentric	2010-2021	116	66.7 (26-86)	59.5%
Aversano et al. *[15]*	Retrospective	Italy	Monocentric	2013-2023	41	71.53 (30-85)	61%

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Cui et al. *[34]*	Retrospective	USA	Multicentric	2015-2023	62	66 (42-87)	46.8%

Table 2. Clinicopathological and endoscopic ultrasound features of the included studies.

Reference	Lesions, n	Primaries (Kidney/Lung/Colon/Breast/ other)	Mean lesion size (range), mm	Location (head (uncinate, neck)/body/ tail/multiple)	Focality (monofocal/multifocal)	EUS morphology	CH-EUS pattern	Final diagnosis
Palazzo et al. [10]	16	4/0/0/0/3	40 (15-60)	5/0/1/0	6/1	Isoechoic moderately hypoechoic, homogeneous, rounded and well delineated and associated with peripheral intensification or no attenuation. Hypervascular.	-	Pre-FNA era, focus on morphology (6 surgery, 1 CT biopsy)
Fritscher-Ravens et al. [4]	12	3/1/1/2/4	28 (18-40)	10/2/0/0	-	Hypoechoic (2); Hypoechoic and inhomogenous (10)	-	EUS-FNA
Bechade et al. [35]	29	11/0/0/0/0	-	5/1/0/5	5/6	Rounded, solid, well-defined, homogeneous, hypoechoic, or isoechoic lesions, with peripheral enhancement of the US beam	-	EUS-FNA (9/11)
Mesa et al. [5]	11	1/4/1/2/3	-	6/3/1/1	-	-	-	

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Mousa et al.[22]	31	10/4/4/2/2	-	-	14/3	Hypoechogenic (9), well-limited borders (6), posterior enhancement (3), hyperechogenic aspect (1), homogeneous aspect (1)	-	EUS-FNA (N = 6), CT-guided biopsy (N = 2), ultrasound-guided biopsy (N = 3), duodenoscopy (N = 3)
DeWitt et al.[12]	29	10/4/2/0/8	36,13 (16-70)	15/5/3/1	22/2	Borders: poorly defined in 13 (54%); well defined in 11 (46%). Hypoechoic 20 (83%); 1 metastatic RCC hyperechoic; 1 anechoic; 2 mixed hypoechoic/ anechoic 2 lesions.	-	EUS-FNA
Layfield et al. [40]	17	8/2/0/0/9	-	6/4/0/4	-	-	-	EUS-FNA
Hijoka et al. [31]	38	7/6/1/2/12	34.4 (13-90)	9/13/3/3	23/5	Regular borders in 18 (64.2%), clear boundary in 26 (92.8%), homogeneous internal echoic pattern in 14 (50.0%). Cystic components in 8 (28.5%), MHZ in 10 (35.7%); calcifications in 3 (10.7%). Distal MPD dilation in 10 (35.7%),	--	22 (78,5%) EUS-FNA; 12 (42.8%) surgical resection

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						distal parenchymal atrophy in 3 (10.7%).		
Pan et al. [32]	6	2/2/1/1/0	-	1/3/1/1	5/1	-	-	-
Ardengh et al. [39]	37	5/6/4/3/17	42 (12-127)	22/9/4/0/2	34/3	Hypoechoic (34), with well- defined borders (23) and heterogeneous (22)	-	EUS-FNA (Final diagnosis in 94% of cases)
El Hajj et al. [25]	72	21/8/4/3/13	34 (4-80)	34/8/7/0	38/11	Hypoechoic 39 (80%); mixed hypoechoic/anechoic 7 (14%), hyperechoic 2 (4%); anechoic in 1 (2%). Regular borders in 27 (55%), irregular in 22 (45%).	-	EUS-FNA
Atiq et al. [30]	23	4/4/4/0/11	39.1 (16-90)	10/8/4/1	18/5	Solitary pancreatic lesion in 18 (78.3%). Hypoechoic in 16 (69.6%), anechoic in 2 (8.7%), mixed echogenicity in 5 (21.7%).	-	21 EUS-FNA; 1 CT FNA; 1 clinical course
Fusaroli et al.[37]	11	3/0/2/2/4	29.7 (10-50)	2/8/0/0/1	11/0	Hypoechoic with homogeneous in echotexture (10). Regular margins (9). Irregular margins in breast cancer metastasis.	Hypoenhancing with heterogeneous pattern 4; Hypoenhancing with homogeneous pattern 2; Hyperenhancing with homogeneous pattern 4	EUS-FNA and surgical

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							(RCC); Isoenhancing with heterogeneous pattern 1.	
Waters et al. [26]	66	27/9/5/6/19	-	30/15/17/1	65/1	-	-	All EUS-FNA
Smith et al. [13]	22	14/1/2/0/5	37 (15-65)	-	16/6	-	-	All EUS-FNA
Alomari et al. [38]	31	8/7/2/2/12	43 (11-100)	13/3/2/13	17/14	-	-	EUS - FNA (Final diagnoses in 94% of cases)
Raymond et al. [28]	16	3/6/2/0/5	42 (12-109)	7/5/4/0	15/1	-	-	EUS FNA 8; CT FNA 3; CT CNB 5;
Sekulic et al. [27]	25	10/2/4/1/8	15 (9.5-26) (median, IQR)	17/11/9/7	18/7	Hypoechoic, heterogeneous, and with variably defined borders	-	EUS-FNA
Hou et al. [29]	30	11/5/2/2/10	-	12/7/8/2	-	-	-	EUS-FNA (93.3% accuracy)
Betes et al. [14]	44	12/10/5/1/16	28.63 ± 19.4	22/8/7/7	34/10	-	-	EUS-FNA
Ioakim et al. [36]	10	3/1/1/0/2	-	-	-	All lesions, except one that showed a mixed solid and cystic morphology, appeared solid.	-	EUS-FNA
Abdallah et al. [33]	12	5/1/0/1/1	31.88 ± 25.85	3/2/2/0	6/2	-	-	EUS-FNA
Teodorescu et al. [20]	20	6/5/3/1/5	30 (22–	12/2/6/0	14/6	Hypoechoic and hypervascula	Arterial hyperenhancement in	EUS-FNA

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			36) (median, IQR)			rized in 11 (55%)	11 (55%); hypoenhancement in 9	
Spadaccini et al. [16]	205	75/7/9/7/18	25.4 ± 15.2	137/50/49/0	59/57	Hypoechoic (95), hypervascular (60), with a heterogeneous pattern (54), well-defined borders (52)	-	82 EUS-FNB; 12 EUS-FNA; 15 surgery.
Aversano et al. [15]	41	18/4/4/2/13	30 (IQR 27)	17/7/5/12	26/15	Hypoechoic (97.56%), oval-shaped (54.66%), well-defined borders (60.98%), predominantly hypervascular.	-	35 EUS-FNA/B; 2 surgery; 3 clinical history and appearances
Cui et al. [34]	62	11/9/2/3/37	34 (6-130)	26/13/13/10	46/16	-	-	EUS-FNB

3.1. Population Characteristics

The median age at diagnosis of PM ranged from 57 to 72 years, with a slight male predominance [4,5,12–16,20,22,25–40]. The largest included studies identified PM in approximately 1–6% of pancreatic masses sampled [5,10,13–15,20,26–28,30,34,38–40]. Most patients were asymptomatic or presented with non-specific symptoms such as abdominal pain, weight loss, or jaundice [12,14–16,25,27,30,35,39]. In several series, over two-thirds of cases were incidentally detected during oncologic follow-up imaging [16,27,30,36]. Notably, a long-time interval between the diagnosis of the primary tumor and the detection of PM, up to 25 years, was reported, especially among patients affected by renal cell carcinoma (RCC) [16,25,26,28]. Interestingly, Betes et al. noted that PM from lung carcinoma had a significantly shorter latency time than those from RCC [14]. Synchronous presentations, in which the PM was discovered concurrently with or shortly after the primary tumor, were observed in 10–30% of cases [15,16,25].

3.2. Primary Tumors

RCC consistently emerged as the predominant source of PM, accounting for 17–65% of cases among the included studies [5,10,15,16,22,25–29,33,36,40]. Other common primaries included lung carcinoma (8-38%), colorectal adenocarcinoma (4-18%), breast carcinoma (4-18%), melanoma (3-14%), and sarcomas or lymphomas (each 1-10%) [4,5,10,12–16,20,22,25–39]. Less common primaries reported include gastric adenocarcinoma, hepatocellular carcinoma, prostate, thyroid, and gynecologic tumors [13–15,31,39]. The recent multicenter study by Cui et al. added valuable histopathologic detail, emphasizing the wide spectrum of tumors potentially metastasizing to the pancreas. Indeed, epithelial neoplasms represented 73% of cases, most often RCC, lung

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adenocarcinoma, and Müllerian-type carcinomas, while non-epithelial metastases originated from hematologic malignancies, sarcomas, and melanoma [34].

3.3. Size, Localization and Focality

Mean lesion size ranged from 15 to 42 mm, with extremes from a few millimeters to over 13 cm [4,10,12–16,20,25,27,28,30,31,33,34,37–39]. Lesions were distributed throughout the gland, with a slight predilection for the pancreatic head (17– 83%), followed by the body (9–73%) and the tail (7–27%) [4,5,12,14–16,20,25–34,37–40]. Multifocality was observed in approximately 10–25% of cases, particularly in RCC metastases [13,25,27,36,39].

3.4. Endoscopic Ultrasound Morphological Features

EUS provides a detailed morphological characterization of PM. PM are typically described as well-demarcated, hypoechoic, and homogeneous lesions, often oval or round in shape [4,10,12,15,16,20,22,25,27,30,31,35,37,39]. As compared to PDAC, which is typically irregular and hypoechoic with poorly defined borders, PM exhibit a clearer interface with surrounding parenchyma (marginal hypoechoic zone, MHZ) [31]. While PDAC is mostly hypovascular, PM frequently appear hypervascular [10,15,16,20]. Notably, pancreatic duct dilatation and parenchymal atrophy, hallmarks of PDAC, were uncommon in metastases, even when lesions were located within the head [31,33]. These features, together with well-defined margins, should promptly raise suspicion for a secondary rather than a primary pancreatic tumor. Aversano et al. [15] recently proposed a composite set of EUS features for PM, noting that the combination of hypoechoic echogenicity, hyper or moderate vascularity, oval or roundish shape with well-defined margins, and hardness on elastography was strongly associated with secondary lesions. Nevertheless, they emphasized that EUS morphology alone is insufficient to differentiate PM from pancreatic neuroendocrine tumors or some solid pseudopapillary neoplasms, underscoring the final need for histologic confirmation.

EUS morphological features of PM are illustrated in Figure 1.

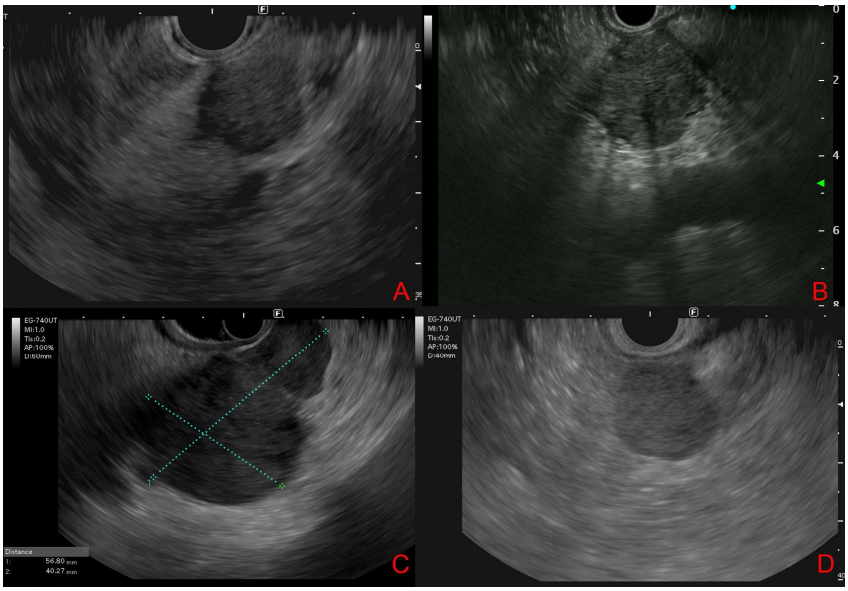

Figure 1. Endoscopic ultrasound features of pancreatic metastases. A-B: From renal cell carcinoma (solid, round, well-defined hypoechoic lesions). C: From hepatocellular carcinoma (bilocular hypoechoic lesion). D: From Lymphoma (nodular, hypo-isoechoic lesion with a relatively well-defined boundary).

3.5. Contrast-Enhanced Endoscopic Ultrasound Features

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CH-EUS has a well-known added value to the evaluation of pancreatic masses and, consequently, of PM, providing valuable information on their vascularity. Studies assessing CH-EUS in PM reported that the majority of metastatic lesions, especially from RCC, display hyperenhancement in the arterial phase [20,37], followed by rapid washout [20]. This vascular pattern contrasts sharply with the hypoenhancement typically observed in PDAC, which reflects its desmoplastic and hypovascular stroma [20]. In the study from Fusaroli et al. [37], hypervascularity was a consistent feature of RCC metastases, while hypovascular or hypo- or isoenhancing patterns were more common in PM from colorectal or breast carcinoma, concluding that the finding of a hyperenhancing lesion in a patient with a previous cancer history, especially if renal or hematological, should prompt EUS-TA.

The CH-EUS behavior of solid pancreatic lesions is illustrated in Figure 2.

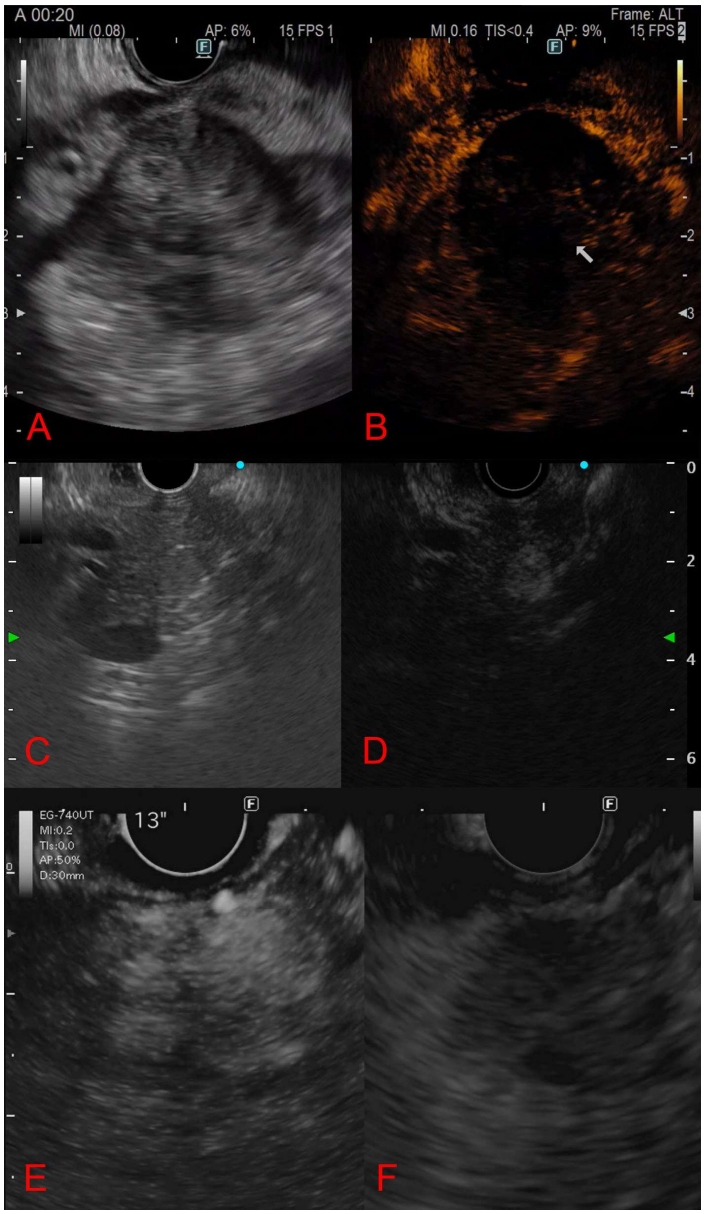

Figure 2. Contrast-enhanced endoscopic ultrasound behavior of solid pancreatic lesions. A-B: Adenocarcinoma (hypoechoic lesion with ipo-enhancement). C-D: Neuroendocrine tumor (hyper-enhancement in arterial phase). E-F: Pancreatic metastasis from renal cell carcinoma (arterial hyperenhancement with heterogeneous distribution).

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3.6. Diagnostic Yield and Final Diagnostic Method

EUS-TA (EUS-FNA/B) is universally regarded as the cornerstone of diagnosis for PM [12,14,15,25]. Early experience from Fritscher-Ravens et al. [4] reported a EUS-FNA sensitivity at 88% with near-perfect specificity and negligible complication rates. Following single-center and multicenter studies [25,29,30,38,39] confirmed accuracy of 85–92%, with diagnostic material obtained in over 90% of cases. More recent studies [15,16,34] consistently exceed 90–95% diagnostic yield, mainly due to EUS-FNB availability, larger-gauge systems, and improved cell-block preparation. Where described, the median number of needle passes through the lesion ranged from 2 to 3 [15,16,25,27,28,31,33,35,39] The addition of immunohistochemistry (IHC) is critical to determine the primary origin, especially in patients with prior malignancies or ambiguous morphology [16,34]. In 2025, Cui et al. [34] showed the morphological overlap between PM and PDAC, emphasizing that EUS-FNB specimens are sufficient for extended IHC and even molecular testing, thereby confirming the current shift from cytology to histology-based diagnosis. Currently, EUS-FNB is the preferred modality for EUS-TA in most centers when PM is suspected, as it provides more intact tissue cores, allowing for cell block preparation, immunostaining, and molecular comparison with prior specimens [15,16].

3.7. Treatment and Outcomes

Management of PM should be patient-tailored and specifically guided by the primary tumor type, disease burden, and patient performance status in a multidisciplinary approach. Surgery should be considered whenever a potentially curative resection is feasible, particularly in RCC, with a reported good long-term survival after pancreatectomy in several studies [14,22,28,38]. Conversely, non-surgical strategies such as systemic anticancer therapy, stereotactic radiotherapy, or endoscopic palliation, is generally applied in disseminated disease [4,15,27]. Prognosis is poor especially in small-cell lung or breast cancer PM, matching that of the metastatic primary.

4. Discussion and Conclusions

Over the past decades, EUS has redefined the diagnostic approach to PM, converting a historically post-surgical or autoptic finding into a clinically feasible diagnosis [1,2]. Although PM currently represent only 1–6% of pancreatic malignancies in large EUS series [5,10,13–15,20,26–28,30,34,38–40], the growing population of long-term cancer survivors has increased their recognition. RCC emerged as the most common primary tumor originating PM, representing 17-65% of all diagnosis [5,10,15,16,22,25–29,33,36,40]. This evidence has remained stable over time, reflecting the prolonged survival of RCC patients and the tumor's particular tropism for the pancreatic tissue [41]. Early reports like Fritscher-Ravens et al. [4], Mesa et al. [5] and DeWitt et al. [12] demonstrated the feasibility of EUS-FNA, but subsequent studies have consolidated its role as the first-line diagnostic tool. Large series and multicenter studies have confirmed a diagnostic accuracy exceeding 90%, with negligible complication rates [25,29,30,39,40]. EUS-FNB has been progressively integrated to FNA, enabling more tissue to be sampled and a major feasibility and accuracy of IHC and molecular comparison with the primary tumor. In the recent studies by Spadaccini et al. [16] and Cui et al. [34], EUS-FNB provided sufficient tissue for extended immunophenotyping, marking a shift from cytology to histology-based diagnosis. These data align with those from previous literature findings, which have underscored the pivotal role of IHC in confirming the metastatic nature of pancreatic lesions and differentiating them from PDAC, when morphology alone was insufficient [27,40]. Advanced imaging techniques have also provided a significant contribution to the characterization of these lesions. In particular, CH-EUS allowed a real-time functional study, enabling a more accurate assessment of vascularity. Several studies have shown that most PM, especially those from RCC, display hyperenhancement in the arterial phase, contrasting with the hypovascular pattern of PDAC [20,37]. Fusaroli et al. [37] and Teodorescu et al. [20] confirmed that CH-EUS increases diagnostic confidence but cannot replace tissue confirmation, as hypovascular

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metastases from colorectal or breast carcinoma remain a frequent source of false negatives. These findings emphasize that the strength of EUS lies not only in morphology but also in its capability to integrate vascular and cytologic information during a single procedure. From a clinical standpoint, EUS-based diagnosis directly influences management strategies. The detection of a secondary tumor to the pancreas rather than primary pancreatic tumor significantly alters prognosis and treatment [24,42]. A multidisciplinary team approach is crucial for the proper diagnosis and treatment of PM. Endosonographers, radiologists, pathologists, oncologists and surgeons should deeply cooperate to interpret imaging and histological findings in the context of the patient's history. Despite the marked progress achieved, current evidence is limited by the retrospective nature of all the included studies, their relatively small sample size, and heterogeneity in reporting. Only a few studies have prospectively compared FNA and FNB or standardized CH-EUS descriptors [20,43–46].

Artificial intelligence (AI) is also emerging as an ancillary technique in EUS especially after the introduction of Convolutional Neural Network (CNN) technology which have completely revolutionized image classification. In fact, CNN automatically learn hierarchical features from images, allowing for more accurate and robust classification results and high-performance prediction, allowing real-time lesion characterization, segmentation, and classification [47]. There is a scan of literature evidence about the detection of PM with AI. In particular, Kuwahara et al. published a retrospective study about the application of CNN using EfficientNetV2-L (22 000 images generated from 933 patients), able to differentiate PDAC from other benign and malignant lesions, including PM, achieving an accuracy of 91.0%, sensitivity of 94% and specificity of 82% [48].

In conclusion, EUS with EUS-TA currently represents the mainstay for the accurate diagnosis of PM, combining a very high accuracy with minimal morbidity. Furthermore, its combination with CH-EUS and modern EUS-FNB devices allow precision in both macroscopic and microscopic characterization, enabling more tailored therapeutic decisions. Future large multicentric prospective studies should aim to harmonize reporting standards, validate quantitative perfusion and elastographic metrics, and explore molecular profiling from EUS-FNB cores as a platform for personalized oncology.

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Abbreviations

The following abbreviations are used in this manuscript:

PM	Metastases to the pancreas
EUS	Endoscopic ultrasound
PDAC	Primary pancreatic ductal adenocarcinoma
EUS-TA	EUS-guided tissue acquisition
FNA	Fine-needle aspiration
FNB	Fine-needle biopsy
CH-EUS	Contrast-enhanced EUS
MeSH	Medical Subject Headings

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RCC	Renal cell carcinoma
MHZ	Marginal hypoechoic zone
IHC	Immunohistochemistry
AI	Artificial Intelligence
CNN	Convolutional Neural Network

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