Endoscopic ultrasonography as additional preoperative workup is valuable in half of the patients with a pancreatic body or tail lesion

Quisette P. Janssen1,*, Myrte Gorris2,3,*, Bram L.J. van den Broek1, Marc G. Besselink2, Olivier R. Busch2, Casper H.J. van Eijck1, Bas Groot Koerkamp1, Jeanin E. van Hooft3,4 & Lydi M.J.W. van Driel5

1Department of Surgery, Erasmus MC Cancer Institute, University Medical Center Rotterdam, Dr. Molewaterplein 40, 3015 GD, Rotterdam, 2Department of Surgery, Cancer Center Amsterdam, Amsterdam UMC, University of Amsterdam, Meibergdreef 9, 1105 AZ, Amsterdam, 3Department of Gastroenterology and Hepatology, Amsterdam Gastroenterology Endocrinology Metabolism, Amsterdam UMC, University of Amsterdam, Meibergdreef 9, 1105 AZ, Amsterdam, 4Department of Gastroenterology and Hepatology, Leiden University Medical Center, Albinusdreef 2, 2333 ZA, Leiden, and 5Department of Gastroenterology and Hepatology, Erasmus MC Cancer Institute, University Medical Center Rotterdam, Dr. Molewaterplein 40, 3015 GD, Rotterdam

Abstract

Background: The management of pancreatic body and tail lesions is underexposed. It remains unclear whether endoscopic ultrasonography (EUS) increases the accuracy of the preoperative workup. This study assessed the diagnostic value and safety of EUS in addition to cross-sectional imaging in a surgical cohort of patients with pancreatic body or tail lesions.

Methods: A multicenter retrospective cohort study was performed of patients who underwent distal pancreatectomy from 2010 to 2017. The composite primary outcome was the additional value of EUS, defined as: (a) EUS confirmed an uncertain diagnosis on cross-sectional imaging, (b) EUS was correct in case of discrepancy with cross-sectional imaging, or (c) EUS provided tissue diagnosis for neoadjuvant treatment. Furthermore, serious adverse events and needle tract seeding were assessed.

Results: In total, 181 patients were included, of whom 123 (68%) underwent EUS besides cross-sectional imaging. Postoperative pathology was heterogeneous: 91 was malignant, 49 premalignant, 41 benign. Most lesions were solid (n = 117). EUS had additional value in 59/123 (48%) patients; 27/50 (54%) of cystic and 32/73 (44%) of solid lesions. No serious adverse event or needle tract seeding following EUS occurred.

Conclusion: EUS had additional value besides cross-sectional imaging in half of the patients and showed low associated risks.

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Correspondence

Lydi M.J.W. van Driel, Department of Gastroenterology and Hepatology, Erasmus MC Cancer Institute, University Medical Center Rotterdam, Dr. Molewaterplein 40, 3015 GD, Rotterdam, the Netherlands.
E-mail: l.m.j.w.vandriel@erasmusmc.nl

Introduction

The management of lesions in the pancreatic body or tail is underexposed in literature. Although distal pancreatectomy is less extensive than surgery for pancreatic head or neck tumors, it is still associated with an estimated major complication rate of 20% and mortality of 3%.1,2 Moreover, longterm morbidity includes endocrine and exocrine pancreatic insufficiency with associated increased cardiovascular risk.3 The majority of pancreatic lesions are benign or low-risk lesions for which a conservative approach can be justified. Unfortunately, differentiating benign from high-risk premalignant or malignant

* These authors share first authorship.
lesions, which do require surgical intervention, can be challenging. As a consequence, surgical overtreatment for low-risk pathology is a considerable problem in patients with pancreatic body or tail lesions, even if international guidelines are applied.4–7

To prevent unnecessary major abdominal surgery, a thorough diagnostic workup is essential. This often includes cross-sectional imaging techniques, such as computed tomography (CT), magnetic resonance imaging (MRI), and/or magnetic resonance cholangiopancreatography (MRCP). Although endoscopic ultrasonography (EUS) is an invasive modality, it is used increasingly due to several advantages over cross-sectional imaging only. EUS has the ability to create high-quality images because of its close proximity to the lesion. Hence, EUS provides particularly good examination of cyst morphology and can differentiate mural nodule-like mucus lumps from true mural nodules when intravenous contrast is used simultaneously.8,9 Furthermore, it allows for EUS-guided tissue acquisition (TA) to provide a pathological diagnosis, which is helpful in case of unclear imaging and even necessary to start neoadjuvant treatment in case of malignancy. Last, cyst fluid sampling can help distinguish different cyst etiologies.10,11 On the other hand, additional evaluation by EUS is not always required and may even be harmful. Potential disadvantages of EUS include the possibility of sampling errors or nondiagnostic sampling, adverse events (e.g. acute pancreatitis, infection, bleeding) in 1–4% of patients, and possible treatment delay.12,13 In addition, needle tract seeding following transgastric EUS-guided TA for pancreatic body or tail tumors has been described in several case reports.14–18 The actual risk of needle tract seeding remains unclear, with a number of retrospective studies reporting varying results and conclusions.19–21 Although it is generally considered a rare phenomenon, it remains an area of concern especially for pancreatic body or tail tumors since the puncture route from transgastric TA is situated outside of the surgical resection bed. In contrast, the transduodenal puncture route for pancreatic head or neck tumors is often resected.

Clinicians need to consider the pros and cons of any additional examination. Studies describing the value of EUS following cross-sectional imaging specifically in patients with a pancreatic body or tail lesion are lacking. Therefore, it remains unclear how often EUS provides the correct diagnosis in case of an uncertain or incorrect diagnosis based on cross-sectional imaging, or provides a definite tissue diagnosis necessary for neoadjuvant treatment. In these scenarios, EUS can be considered of additional diagnostic value, thereby guiding the appropriate treatment plan and potentially even preventing unjustified major surgery. We aimed to determine the diagnostic value of EUS in addition to cross-sectional imaging in patients who underwent a distal pancreatectomy for a focal lesion in the pancreatic body or tail.

Methods

Study design and patients

We performed a multicenter retrospective cohort study of consecutive patients who underwent a distal pancreatectomy for a pancreatic body or tail lesion between April 2010 and August 2017 at the Erasmus MC University Medical Center and Amsterdam UMC, location AMC. All patients underwent a resection based on the guidelines that were commonly used at time of study protocol.22–24 The local institutional review board of the Erasmus MC University Medical Center approved the study and waived the requirement to obtain informed consent.

Data collection and definitions

Baseline characteristics and data on clinical presentation, diagnostic workup, postoperative diagnosis, and clinical follow-up were collected retrospectively. Lesions were classified as solid or cystic based on cross-sectional imaging reports. For lesions with both solid and cystic features, the dominant component was determined after independent review of the imaging reports and images by the researchers. The first mentioned diagnosis in the cross-sectional imaging report was used as the most likely radiologic diagnosis. For patients who underwent both a CT- and MRI-scan, the last available report prior to resection was used. For the most likely endoscopic diagnosis, both the endoscopic report, TA, and cystic fluid analysis were taken into account, relying on the treating physicians’ report of the most likely diagnosis.25 Disagreements on both lesion type and the most likely radiologic and endoscopic diagnoses were resolved through discussion and consensus in a new multidisciplinary meeting including two gastroenterologists (JvH and LvD with 18 and 4 years of experience in HPB-related diseases) and a hepatopancreato-biliary surgeon (BGK with 10 years of experience). The resection was considered justified if postoperative pathological examination showed the presence of malignancy, high-grade dysplasia, pNET, MCN, SPN, or if the resection was performed for improvement of symptoms in case of a benign lesion. Lesions with low- or moderate-grade dysplasia and benign lesions that were not resected for symptom relief were considered unjustified or premature resections, since these lesions are regarded to have very low risk (<5%) of malignant progression and would have therefore been manageable with observation.22,26,27 Needle tract seeding was defined as any highly suspect or pathologically proven gastric wall recurrence without connection to the pancreatic remnant in patients who underwent preoperative EUS-guided TA for a malignant tumor (i.e. PDAC, metastasis from other primary tumors). Adverse events grade following the EUS procedure were defined and graded according to the Clavien-Dindo classification.1

Outcomes and statistical analysis

The primary outcome was the percentage of patients with additional diagnostic value of EUS, defined as a composite of three scenarios: (a) EUS confirmed an uncertain diagnosis on
cross-sectional imaging, (b) EUS provided the correct diagnosis in case of discrepancy between cross-sectional imaging and EUS, or (c) EUS-guided TA provided a correct tissue diagnosis necessary for neoadjuvant treatment. In contrast, EUS was considered of no additional diagnostic value if: (d) EUS did not provide any complementary diagnostic information, or (e) if EUS provided an incorrect diagnosis. The primary outcome was calculated based on patients who underwent preoperative EUS. Furthermore, a sensitivity analysis was performed including all patients irrespective of preoperative EUS.

Secondary outcomes were the percentage of patients with a justified resection based on final pathological examination (i.e. for all patients, irrespective of diagnostic workup) and the additional value of EUS for each preoperative radiological diagnosis (i.e. for patients who underwent EUS). Furthermore, we assessed how often EUS imaging and EUS-guided TA correctly changed the treatment plan (i.e. a justified resection or neoadjuvant treatment). Last, we assessed the potential advantages of EUS, including the rate of needle tract seeding and serious adverse events grade 3 or higher following EUS.

Categorical variables were presented as frequencies and proportions. Continuous variables were presented as medians with interquartile range (IQR). Statistical analysis was performed with SPSS Version 25.0 statistic software package.

Results

Patient characteristics
We included 181 patients who underwent distal pancreatectomy between April 2010 and August 2017. The characteristics of the 181 included patients are described in Table 1, section A. Of all patients, 117 (65%) had a solid lesion and 64 (35%) had a cystic lesion.

Diagnostic workup
The characteristics of the diagnostic workup are described in Table 1, section B. Preoperatively, CT was performed in 160 patients (88%), MRI/MRCP in 72 patients (40%), and both CT and MRI/MRCP in 53 patients (29%). In addition to cross-sectional imaging, EUS was performed in 123 patients (68%), more frequently in patients with a cystic lesion (solid: 73 (62%); cystic: 50 (78%)). Tissue acquisition was performed in 78 patients (43%). EUS-guided TA was performed in a comparable proportion of solid and cystic lesions (solid: 45%; cystic: 39%).

Postoperative pathology and justified resection
The postoperative pathology is shown in Table 1, section C. Ninety-one patients (50%) had a malignant diagnosis, including PDAC (n=43) and pNET (n=44). Forty-nine patients (27%) had a premalignant diagnosis. Forty-one patients (23%) had benign diagnoses, mostly pancreatitis (n=25). Based on final pathology examination, resection was justified in 148 patients (82%). By lesion type, 105 patients underwent a justified resection, compared with 67% with cystic lesions. Within the subgroup of 58 patients (32%) who underwent resection without preoperative EUS, the diagnosis based on cross-sectional was correct in 50 patients (86%). Moreover, the resection was justified for the vast majority of this subgroup, yet five patients (9%) underwent an unjustified resection (Suppl. Table 1).

Additional diagnostic value of EUS
Table 2 shows the percentage of patients with additional diagnostic value of EUS by lesion type, with further specifications on how EUS provided this additional value in Suppl. Table 2. Overall, EUS was considered of additional diagnostic value in 59 patients (48%) who underwent EUS. By lesion type, EUS was of additional value for 32 patients (44%) with a solid lesion and 27 patients (54%) with a cystic lesion. For both lesion types, the additional value of EUS was mostly based on providing the correct diagnosis in case of discrepancy with cross-sectional imaging (b). In total, 53 patients had discrepancies between the cross-sectional imaging and endoscopic diagnosis, of whom EUS provided the correct diagnosis in 30 (57%). More specifically, providing the correct diagnosis resulted in a change of treatment plan in 20 patients (27%) with a solid lesion and 14 patients (28%) with a cystic lesion. This change of treatment plan was mostly based on EUS imaging for patients with a cystic lesion versus EUS-guided TA in patients with a solid lesion. Without taking into account the inherent obvious value of EUS-guided TA necessary for neoadjuvant treatment, EUS was of additional value in 25 patients (34%) with a solid lesion and 27 patients (54%) with a cystic lesion. In patients with no additional value of EUS (n=64), EUS was correct but provided no additional information in 54 patients (d: 44%), whilst the diagnosis based on EUS was incorrect in 10 patients (e: 8%) (Suppl. Table 3). In a sensitivity analysis based on all patients (i.e. including patients who did not undergo EUS), EUS was of additional value in 32 patients (27%) with a solid lesion and 27 patients (42%) with a cystic lesion (Suppl. Table 4).

Additional diagnostic value of EUS by cross-sectional radiological diagnosis
Table 3 shows the percentage of patients with additional value of EUS by cross-sectional radiological diagnosis. For solid lesions, EUS was of additional value in 25 patients (47%) with radiological suspicion of a malignant or premalignant lesion and in seven patients (35%) with suspicion of a benign lesion. For cystic lesions, this was the case in 20 patients (49%) with suspicion of a malignant or premalignant lesion and in seven patients (78%) with suspicion of a benign lesion.

Disadvantages of EUS
Out of the 22 patients who underwent EUS-guided TA with a malignant final diagnosis, three patients were lost to follow-up and the remaining 19 did not show evidence for needle tract seeding. No serious adverse event following EUS was reported.
Discussion

This multicenter retrospective cohort study aimed to assess the diagnostic value of EUS in addition to cross-sectional imaging in a heterogeneous surgical cohort of patients with pancreatic body or tail lesions. EUS was of additional diagnostic value in half of all patients who underwent an EUS for varying pancreatic etiologies. In this cohort, the value of EUS seemed somewhat more pronounced in patients with cystic lesions. Corresponding with literature, patients with solid and cystic lesions benefited from additional EUS in a different manner. For patients with cystic lesions, EUS imaging mostly provided additional diagnostic value, whereas the supplementary value in solid lesions was mostly based on EUS-guided TA.

Table 1 Patient characteristics

| A. Clinical characteristics | Entire cohort (n = 181) | Solid (n = 117) | Cystic (n = 64) |
|-----------------------------|------------------------|----------------|----------------|
| Age at surgery in years, median (IQR) | 62 (51–69) | 61 (49–68) | 64 (52–71) |
| Female, n (%) | 102 (56%) | 57 (49%) | 45 (70%) |
| First presentation, n (%) | | | |
| Symptomatic | 96 (53%) | 64 (55%) | 32 (50%) |
| Incidental | 65 (36%) | 40 (34%) | 25 (39%) |
| FU for pancreatic cyst | 7 (4%) | 2 (2%) | 5 (8%) |
| FU for mutation/familiar PDAC | 8 (4%) | 6 (5%) | 2 (3%) |
| FU for lesion outside of pancreas | 5 (3%) | 5 (4%) | 0 |
| B. Diagnostic workup | | | |
| Imaging modalities, n (%) | | | |
| CT | 160 (88%) | 112 (96%) | 48 (75%) |
| MRI | 72 (40%) | 39 (33%) | 33 (52%) |
| CT/MRI + EUS | 123 (68%) | 73 (62%) | 50 (78%) |
| CT/MRI + EUS + TA | 78 (43%) | 53 (45%) | 25 (39%) |
| Attempts of TA, 1 vs. 2, n | 71 vs. 7 | 49 vs. 4 | 22 vs. 3 |
| C. Postoperative pathology | | | |
| Malignant lesions | 91 (50%) | 79 (68%) | 12 (19%) |
| PDAC | 43 (24%) | 34 (29%) | 9 (14%) |
| pNET | 44 (24%) | 41 (35%) | 3 (5%) |
| Metastasis other primary | 4 (2%) | 4 (3%) | 0 |
| Premalignant lesions | 49 (27%) | 8 (7%) | 41 (64%) |
| IPMN – HGD | 4 (2%) | 0 | 4 (6%) |
| IPMN – LGD or MGD | 15 (8%) | 1 (1%) | 14 (22%) |
| MCN | 23 (13%) | 0 | 23 (36%) |
| SPN | 7 (4%) | 7 (6%) | 0 |
| Benign lesions | 41 (23%) | 30 (26%) | 11 (17%) |
| Pancreatitis | 25 (14%) | 23 (20%) | 2 (3%) |
| Pseudocyst | 1 (1%) | 0 | 1 (2%) |
| SCN | 6 (3%) | 0 | 6 (9%) |
| Other benign lesion or no tumor | 9 (5%) | 7 (6%) | 2 (3%) |
| Justified resection, n (%) | 148 (82%) | 105 (90%) | 43 (67%) |

Abbreviations: CT = Computed Tomography. EUS = Endoscopic ultrasonography. Fam. = family. FNA = fine needle aspiration. FNB = fine needle biopsy. FU = follow-up. HGD = high-grade dysplasia. IPMN = Intraductal papillary mucinous neoplasm. IQR = interquartile range. LGD = low-grade dysplasia. MCN = mucinous cystic neoplasm. MGD = moderate-grade dysplasia. MPD = main pancreatic duct. MRI = Magnetic Resonance Imaging. N = number of patients. NA = not applicable. PDAC = pancreatic ductal adenocarcinoma. pNET = pancreatic neuroendocrine tumor. SPN = solitary pseudopapillary neoplasm. SCN = serous cystic neoplasia. TA = tissue acquisition.

a Presentation during follow-up for other lesions: neuroendocrine tumor, retroperitoneal fibrosis, renal cell carcinoma, granular tumor esophagus, hemangiopericytoma.

b Two patients had no detectable lesion and one patient had a pathological complete response after induction treatment for pancreatic cancer.
Additional diagnostic value of EUS with or without tissue acquisition

| Diagnosis based on cross-sectional imaging | Entire cohort (n = 123) | Solid (n = 73) | Cystic (n = 50) |
|-------------------------------------------|------------------------|---------------|---------------|
| Malignant                                 | 59 (48%)               | 32 (44%)      | 27 (54%)      |
| PDAC                                      | 20 (16%)               | 10 (13.7%)    | 10 (20%)      |
| pNET                                      | 30 (24%)               | 13 (18%)      | 17 (34%)      |
| Metastases other                          | 9 (7%)                 | 9 (12%)       | 0             |
| GIST                                      | 19 (15%)               | 6 (8%)        | 13 (26%)      |
| Premalignant                              | 15 (12%)               | 14 (19%)      | 1 (2%)        |
| IPMN                                      | 10 (8%)                | 6 (8%)        | 4 (8%)        |
| No change of treatment plan               | 64 (52%)               | 41 (56%)      | 23 (46%)      |
| No additional value                       | 54 (44%)               | 35 (48%)      | 19 (38%)      |
| EUS incorrect                             | 10 (8%)                | 6 (8%)        | 4 (8%)        |
| EUS confirmed an uncertain diagnosis      | 20 (16%)               | 10 (13.7%)    | 10 (20%)      |
| Discrepancy with CT/MRI, EUS correct      | 30 (24%)               | 13 (18%)      | 17 (34%)      |
| Change of treatment plan based on EUS imaging | 9 (7%)                 | 9 (12%)       | 0             |
| Change of treatment plan based on EUS-guided TA | 19 (15%)               | 6 (8%)        | 13 (26%)      |
| Additional value                          | 59 (48%)               | 32 (44%)      | 27 (54%)      |
| No additional value                       | 64 (52%)               | 41 (56%)      | 23 (46%)      |
| d. No complementary information           | 54 (44%)               | 35 (48%)      | 19 (38%)      |
| e. EUS incorrect                          | 10 (8%)                | 6 (8%)        | 4 (8%)        |

Abbreviations: CT = Computed Tomography, EUS = Endoscopic ultrasonography, MRI = Magnetic Resonance Imaging, TA = tissue acquisition.

Further subdivision of total group of patients with additional value of EUS based on discrepancy with CT/MRI (b) and tissue diagnosis for neoadjuvant treatment (c).

(5%) in the current cohort received neoadjuvant treatment for PDAC. With the upcoming use of a neoadjuvant approach and the subsequent need for TA, plus the introduction of newer diagnostic techniques such as EUS-guided ‘through-the-needle’ (Moray) biopsies, the additional value of EUS is expected to even further increase.31–33 Our study underlines the value of EUS at a broad spectrum of diagnoses. Due to the relatively small number of patients per pancreatic etiology, it is difficult to specifically define when to pursue with additional EUS following cross-sectional imaging. In addition, our study was not designed to assess which of all patients presenting with a pancreatic body/tail mass should undergo an additional EUS (i.e., “denominator data”). However, some general conclusions can be drawn from our data. First, in patients with discrepancies between diagnoses based on EUS and cross-sectional imaging, EUS more often provided the correct diagnosis. Second, EUS seems very safe with no serious adverse events and no evidence for needle tract seeding. Third, even further minimizing the adverse effect of EUS, 10 patients with incorrect endoscopic diagnosis underwent a resection that was nonetheless justified based on final pathology or patients’ wish to undergo surgery despite the discussed risk of surgical overtreatment. Together, these arguments further substantiate the recommendation for additional EUS in a broad selection of patients. On the other hand, EUS may be considered unnecessary in patients with a clearly resectable pancreatic mass on cross-sectional imaging, since the benefit of neoadjuvant treatment for early stage PDAC has not been established yet and guidelines recommend upfront surgery followed by adjuvant chemotherapy in these patients.34,35 In the setting of possible neoadjuvant treatment, EUS-guided TA remains essential. Large studies including all consecutive patients who underwent an EUS following CT and/or MRI may further specify the added value of EUS for all patients presenting with a pancreatic body/tail mass, although confirmation bias presents an inevitable challenge in this setting.

Despite thorough diagnostic workup and clinical guidelines, distal pancreatectomy was justified for only 67% of patients with a cystic lesion and in 90% of patients with a solid lesion in our

Table 3 Additional diagnostic value of EUS by cross-sectional radiological diagnosis in patients who underwent EUS

| Diagnosis based on cross-sectional imaging | Solid (n, %) | Cystic (n, %) |
|-------------------------------------------|-------------|---------------|
| Malignant                                 | 22/47, 47%  | 2/3, 67%      |
| PDAC                                      | 10/23, 44%  | 2/3, 67%      |
| pNET                                      | 9/21, 43%   | –             |
| Metastases other                          | 2/2, 100%   | –             |
| GIST                                      | 1/1, 100%   | –             |
| Premalignant                              | 3/6, 50%    | 18/38, 47%    |
| IPMN                                      | –           | 10/23, 44%    |
| MCN                                       | 1/2, 50%    | 8/15, 54%     |
| SPN                                       | 2/4, 50%    | –             |
| Benign                                    | 7/20, 35%   | 7/9, 78%      |
| Pancreatitis                              | 5/14, 36%   | 1/1, 100%     |
| Pseudocyst                                | –           | 5/5, 100%     |
| SCN                                       | –           | 1/3, 33%      |
| No tumor                                  | 2/6, 33%    | –             |
| Total                                     | 32/73, 44%  | 27/50, 54%    |

a Two patients had solid lesions with cystic components, therefore considered as solid lesions.

b One patient had differential diagnosis of IPMN based on EUS yet pancreatitis with enlarged main pancreatic duct based on cross-sectional imaging; therefore considered as cystic lesion.

Abbreviations: EUS = endoscopic ultrasonography, GIST = gastrointestinal stromal tumor. IPMN = Intraductal papillary mucinous neoplasm. MCN = mucinous cystic neoplasm. PDAC = pancreatic ductal adenocarcinoma. pNET = pancreatic neuroendocrine tumor. SCN = serous cystic neoplasia. SPN = solitary pseudopapillary neoplasm.
study. In other words, one out of three patients with a cystic lesion has undergone unjustified or premature major abdominal surgery with associated risk of complications and long-term adverse effects. Other studies assessing surgical overtreatment in focal pancreatic lesions often do not report this outcome specifically for pancreatic body and tail lesions. Within studies reporting this outcome, the proportion of body and tail lesions is 40% or less, thereby limiting direct comparison of our results with other studies. While taking this difference into account, these studies do confirm our finding of surgical overtreatment in a substantial percentage of patients with cystic lesions. A prospective cohort study by Lekkerkerker et al. reported a justified resection in 52 out of 115 patients (45%) with cystic pancreatic lesions. Of note, this study only classified resection of MCN to be justified in case of HGD or cancer whilst all resections for MCN were considered justified in our study based on the commonly used guidelines at time of study protocol. Similarly, a multicenter retrospective study of 251 patients who underwent resection for IPMN showed surgical overtreatment for low-grade dysplasia in 51% of patients. For branch-duct IPMN specifically, a large single-institutional series of 240 patients demonstrated a justified resection percentage of only 22% when the criteria used in our study are applied. Although relatively less common, 12 out of 117 patients (10%) with a solid lesion in our study underwent an unjustified resection. This percentage is comparable to a retrospective study including 75 patients with a pancreatic body or tail lesion suspect for a solid neoplasm who underwent distal pancreatectomy, of whom 11% had a benign lesion. Overall, our study emphasizes the complexity of the clinical management of pancreatic body or tail lesions, especially cystic lesions, balancing between the risk of surgical overtreatment and the clear error of missing a malignancy. Prospective studies may elaborate on the risk of progression or malignant transformation during watchful waiting strategies for specific pancreatic lesions, such as asymptomatic pancreatic cystic lesions (PACIFIC study, www.pacific.net) and small non-functional pNETs (Trial NL9584). To our knowledge, this is the first study that focused specifically on the value of EUS in pancreatic body or tail lesions. Other strengths of our study are the ability to verify the final diagnosis in all patients and the inclusion of a diversity of pancreatic lesions of both cystic and solid etiology. However, the findings of our study should be interpreted in light of some limitations. First, after prospective patient selection, most of the data were collected retrospectively. As a consequence, some outcomes were dependent on the quality of the radiological and endoscopic reports, possibly introducing information bias. Second, selection bias was introduced by including only patients who underwent a resection. However, without this selection, final pathological diagnoses would be missing with subsequent introduction of verification bias. We performed a sensitivity analysis including the 58 patients (32%) who did not undergo EUS following cross-sectional imaging to provide insight in potential additional selection bias for our primary outcome. In this analysis, the value of EUS was obviously lower compared to our primary analysis since only the denominator increased. Still, the additional value remained substantial, especially for cystic lesions. Third, the decision for a resection in this patient cohort was based on applicable guidelines at time of study protocol (i.e. 2010 – 2017). Hence, clinical decision-making may have differed from current practice, wherein neoadjuvant treatment for PDAC is increasing and active surveillance for non-functional asymptomatic pNET <2 cm is considered standard practice.

In conclusion, our study showed that EUS had additional diagnostic value besides cross-sectional imaging in half of the patients who underwent a distal pancreatectomy for a pancreatic body or tail lesion with low associated risks. Therefore, we believe EUS should always be considered in case of an uncertain radiological diagnosis or the need for tissue diagnosis.

Submission declaration
The work has not been published previously in any journal, is not under consideration for publication elsewhere, is approved by all authors and explicitly by the responsible authorities where the work is carried out, and it will not be published elsewhere without written consent of the copyright-holder.

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Conflict of interest
JvH has received research support from Cook Medical and acted as consultant for Cook Medical, Boston Scientific, and Medtronics. QP, MG, BvdB, MB, CvE, ORB, BGK, and LvD declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Author contributions
QJ, MG, CvE, BGK, and LvD were involved in the conception and design of the study; QJ, MG, BvdB, JvH and LvD analyzed and interpreted the data; QJ and MG drafted the article; all authors critically revised the article for important intellectual content and approved the final manuscript.

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Appendix A. Supplementary data
Supplementary data to this article can be found online at https://doi.org/10.1016/j.hpb.2021.10.005.