Digestive and Liver Disease 51 (2019) 1275–1280

Contents lists available at ScienceDirect

Digestive and Liver Disease

journal homepage: www.elsevier.com/locate/dld

Digestive Endoscopy

EUS-guided core biopsies of pancreatic solid masses using a new fork-tip needle: A multicenter prospective study

Milena Di Leo[a,b], Stefano Francesco Crinò[c], Laura Bernardoni[c], Daoud Rahal[d], Francesco Auriemma[a], Loredana Correale[f], Giulio Donato[e], Marco Massidda[a], Andrea Anderloni[a], Erminia Manfrin[g], Elia Armellini[e], Laura Poliani[a], Alessandro Fugazza[a], Rossella Semeraro[a], Pietro Occhipinti[e], Alessandro Repici[a,b], Silvia Carrara[a,*]

[a] Digestive Endoscopy Unit, Division of Gastroenterology, Humanitas Research Hospital, Milan, Italy
[b] Humanitas University, Department of Biomedical Sciences, Milan, Italy
[c] Gastroenterology and Digestive Endoscopy Unit, Pancreas Institute, G. B. Rossi University Hospital, Verona, Italy
[d] Pathological Department, Humanitas Research Hospital, Milan, Italy
[e] Digestive Endoscopy Unit, Ospedale Maggiore della Carità, Novara, Italy
[f] Centro di Prevenzione Oncologica, Turin, Italy
[g] Department of Diagnostics and Public Health, G. B. Rossi University Hospital, Verona, Italy

ARTICLE INFO

Article history:
Received 19 November 2018
Accepted 24 March 2019
Available online 20 April 2019

Keywords:
FNA
FNB
Pancreatic adenocarcinoma
SharkCore needle
Tissue acquisition

ABSTRACT

Background and aim: Endoscopic ultrasound-guided sampling (EUS sampling) is a safe and effective technique. The study aim was to evaluate the presence of a histological core from pancreatic lesions using a new 25G fork-tip needle.
Methods: Observational multicenter prospective and analytical study, including consecutive patients with solid pancreatic masses referred for EUS-guided sampling. At each needle pass, the endoscopist performed macroscopic on-site evaluation (MOSE). The primary outcome was the histological core procurement rates. Secondary outcomes were the evaluation of interobserver agreement between endoscopists and pathologists, adequacy of EUS samples for the diagnosis and post-procedure adverse events.
Results: 100 patients were enrolled in 3 centers. The mean size of the lesions was 28.5 mm (SD 11.7). Final diagnoses were adenocarcinoma (68%), neuroendocrine tumor (21%), inflammatory mass/benign lesions (8.0%), and pancreatic metastasis (3.0%). The pathologists described the presence of a core in 67 samples (67.0% of patients), with poor agreement with MOSE (kappa, 0. 12; 95% CI: 0.03–0.28). The diagnostic accuracy was 93%. We observed 6% of mild adverse events.
Conclusion: The new 25-gauge core needle showed good overall adequacy and a good rate of histological specimens during EUS sampling of solid pancreatic masses, with a minimum number of passes and no major complications. Clinicaltrial.gov number, NCT02946840.

1. Introduction

Endoscopic ultrasound-guided sampling (EUS-guided sampling) is a well-established, safe and effective technique for tissue acquisition from solid pancreatic masses.

Although cytological specimens show excellent adequacy for diagnosis of malignancy, acquisition of a histological core may be required in certain conditions, such as autoimmune pancreatitis, lymphomas, well-differentiated pancreatic ductal adenocarcinoma (PDAC), and rare tumors [1]. The histological core may also theoretically improve the diagnostic performance of EUS-guided sampling, allowing tissue architecture analysis, immunostaining and genetic evaluation. In addition, the core tissue could potentially eliminate the need for ROSE (rapid on-site evaluation) to establish specimen adequacy, reducing the costs and time of the procedure [2].

In an attempt to obtain histological samples, different types of needles have been developed, starting from the reversed bevel modified-Menghini needle, with discordant results in the comparison between the diagnostic yield of FNA and FNB [3,4].

* Corresponding author at: Digestive Endoscopy Unit, Division of Gastroenterology, Humanitas Research Hospital, Via Manzoni, 56, 20089 Rozzano, Milan, Italy.
E-mail address: silvia.carrara@humanitas.it (S. Carrara).

https://doi.org/10.1016/j.dld.2019.03.025
1590-8658/

A new needle with a fork-shaped distal tip including six cutting edges and an opposing bevel has been developed, the SharkCore (Medtronic Parkway, Minneapolis, MN, USA), which has a specific design that enables improved tissue capture and provides better core samples.

Six retrospective studies [5–10] and two prospective pilot studies [11,12] have analyzed the outcomes of this new needle. Their conclusions support the use of the fork-tip needle, which shows good diagnostic accuracy, improves the histology yield, requires fewer needle passes, and has a similar complication rate to standard needles.

To date, there has been no large prospective study aimed at assessing the performance of the 25G fork-tip needle for EUS sampling.

The aim of the present study was to evaluate the ability to obtain a histological sample using the 25G fork-tip needle in patients with solid pancreatic masses.

2. Methods

2.1. Study design and patient population

This was a prospective observational and analytical multicenter study conducted at three Centers (Humanitas Research Hospital, University Hospital of Verona, Azienda Ospedaliera di Novara). All Centers obtained approval by their own Ethics Committees (on 07/06/2016, 09/13/2016 and 02/10/2017, respectively). Before starting enrollment, the study was registered on ClinicalTrials.gov (NCT02946840). Written informed consent was obtained from each patient before the procedure.

The study included consecutive adult (age ≥18, <90 years) patients referred for EUS evaluation of solid pancreatic masses detected by CT and/or MRI.

Exclusion criteria were: (1) uncorrectable coagulopathy as defined by the International Normalized Ratio (INR) >1.5; (2) platelet count $<50{,}000 \times 10^9$/L; (3) inability or unwillingness to provide informed consent; (4) previous biopsy of the lesion with diagnosis of malignancy; (5) pancreatic cystic lesions; (6) pregnancy or breast-feeding.

2.2. EUS procedureand EUS-guided sampling

EUS was performed using the Olympus GF-UCT-180 series linear array echoendoscope (Olympus Europa SE & CO. KG, Hamburg, Germany) in combination with the EU-ME2 echoprocessor (Olympus SE & CO. KG, Hamburg, Germany), or the Pentax EG-3870UTK (Pentax, Hamburg, Germany) series in combination with Hitachi ultrasound machines (Hitachi Europe, Milan). All procedures were performed by the experienced endosonographers who had performed more than 1000 cases of diagnostic EUS and 250 EUS-guided biopsies. Patients with confirmed pancreatic solid mass at EUS underwent EUS sampling with a 25G SharkCore needle combining the fanning and the slow pull technique [13,14]. According to the protocol, three passes were performed for each mass, but all patients with at least one needle pass were included in the analysis (intention-to-treat analysis). After each pass, the stylet was introduced into the needle, the material was released onto a smear slide, and a macroscopic on-site quality evaluation (MOSE) of the specimen was performed by the endoscopist. The following information was recorded: presence of macroscopic visible core, color and size. At MOSE, the core was defined by the endoscopist as a worm-like whitish or yellowish material, not including fluid-like specimens. Size was classified as longer or shorter than 1 cm (Fig. 1).

If "worm-like" material was observed at gross visual assessment, it was placed in a container of 10% neutral buffered formalin fixative for the final histological examination [15]. When bloody material and clots were obtained, they were also collected in formalin. If drop-like material was obtained, it was smeared between two glass slides, fixed with ethanol, and stained with a Papanicolaoustain for cytological analysis. When both a liquid part and a solid micro-fragment were obtained, both cytological and histological evaluations were performed (Fig. 2).

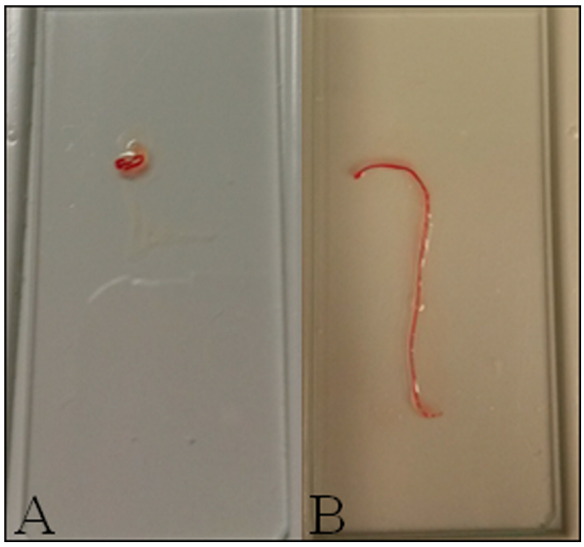

Fig. 1. Macroscopic visible core at macroscopic on-site evaluation: size <1 cm (a) and size >1 cm (b).

2.3. Pathological evaluation

After each pass, the material for histological analysis was fixed in formalin (a box for each pass), embedded in paraffin, sectioned, and stained with hematoxylin and eosin (H&E).

The definition of core was reached during a meeting in which each of the pathologists from the three centers brought slides from 10 consecutive cases performed previously in his or her center.

The pathologists defined "core" as all histological samples with architecturally intact histology, with tissue from the sampled lesion, measuring at least 550 μm the major axis (Fig. S1 — Supplementary material). Micro-fragments <550 μm obtained from paraffinated cell-blocks were not considered as histology (not core) but could still yield a cytological diagnosis based on cell morphology.

2.4. Adverse events (AEs)

Adverse events were defined according to Eloubeidi et al. [16] (detailed in Supplementary material).

2.5. Outcome measures

The primary end-point was the presence of a core adequate for histological evaluation. The secondary outcomes were: to analyze the interobserver agreement between endoscopists and pathologists to assess the presence of a core and its feature; to analyze the adequacy of EUS samples for the diagnosis; post-procedural adverse events.

Final diagnoses were made on one or more of the following in descending order: (1) surgical pathology; (2) cytological or histological EUS samples positive for malignancy; (3) clinical and imaging follow-up during a period of at least one year for patients not treated by surgery.

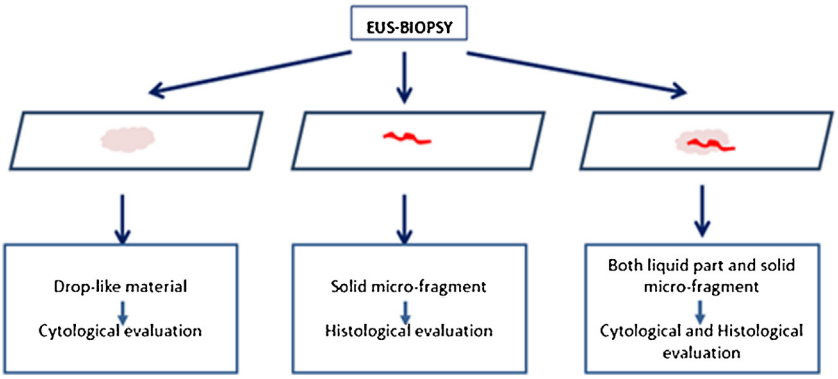

Fig. 2. MOSE macroscopic on-site evaluation. EUS = endoscopic ultrasound

2.6. Sample size calculation

Assuming 50% (worst scenario) as an approximation of adequate samples with the fork-tip needle, a sample size of 100 cases was required to estimate the hypothesized proportion with 10% absolute precision and 95% confidence level (between 40% and 60%). Assuming 80% as an approximation of adequate samples, the planned sample size ensured to estimate this proportion with an absolute precision of 8% (between 71% and 87%). As no previous research was available on which to base these adequate sample estimates, these estimates were only approximations/hypotheses. A sample size of 100 cases would also enable us to detect a 20% difference (80% power, alpha = 0.05) in characteristics between core and non-core sample groups at pathologist evaluation.

Table 1
Characteristics of sampled lesions.

Number of sampled lesions	100
Mean diameter (mm) (SD)	28.5 (11.7)
Lesion location, n (%)	
Head	36 (36)
Uncinate process	20 (20)
Neck	16 (16)
Body	23 (23)
Tail	5 (5)
Mean number of needle passes (range)	3 (1–3)
Final diagnosis	
PDAC	68 (68)
NET	21 (21)
Inflammatory masses or benign disease	8 (8)
Metastasis from other organs	3 (3)

2.7. Statistical analysis

Results for continuous variables were summarized using mean ±SD (standard deviation), and categorical variables using proportions. Fisher's exact test or chi-squared test was used to compare categorical outcomes, while Student's t-test or Wilcoxon rank sum test was used to compare continuous variables. The outcomes were analyzed on a per-patient basis (e.g. at least 1 core sample with 1–3 passes) and on a per-sample basis (including results from all needle passes). The outcomes of each needle pass (per-needle analysis) were also reported and compared.

The kappa coefficient was used to describe the agreement between endoscopic and pathological evaluation. The kappa coefficient is a measure of interobserver agreement, indicating the degree of agreement beyond what would be expected by chance alone. This measure of agreement has a maximum value of 1, where 1 represents total agreement, 0.80–1 excellent agreement, 0.60–0.79 substantial agreement, 0.40–0.59 moderate agreement, 0.2–0.39 fair agreement, 0–0.19 slight agreement, and values near or below 0 indicate no agreement or agreement equivalent to chance.

We analyzed the factors (e.g. sample size at MOSE) that influenced the pathology results for core presence and adequacy using logistic regression analysis. For the purpose of this analysis, data from pathologist evaluation were divided into sample with a core and histologically inadequate samples (including in adequate samples for histology or without any tissue retrieved). Logistic regression analysis was used to determine if there was any association between the presence of a core and data set characteristics. Characteristics were first analyzed with univariable analysis. Variables shown by univariable analysis to be significantly associated (at a significance level of <0.10) with outcome were then entered into a multivariable logistic regression model. Univariable/multivariable analysis was also applied to identify predictive factors for histologically/cytologically adequate material (vs. no material retrieved). Data were presented as odds ratio (OR and 95% confidence intervals) of success (i.e. obtaining a core or adequacy for histology/cytology evaluation) at pathologist evaluation for each category of the explanatory variable (e.g. a worm-like material longer than 1 cm) relative to the odds of the baseline category (e.g. <1 cm). Robust standard errors (by using sandwich estimators of variance) were used for all regression analyses to account for the fact that each case was included in the analysis 3 times (one for each needle pass).

Statistical significance was determined at two-sided p-values <0.05. All statistical analyses were performed using R Core Team (2016). (R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/).

3. Results

The study population included 100 patients equally enrolled between Aug 2016 and May 2017 in the 3 centers. Mean age of patients was 65.1 years (range 22–88) and 56% was female. A total of 100 pancreatic lesions were identified (one per patient).

The characteristics of the lesions are detailed in Table 1. Three needle passes were performed in all but 3 patients, who experienced mild intraprocedural bleeding which precluded the possibility to perform more passes. Therefore, a total of 296 needle passes were collected. The final diagnosis was pancreatic ductal adenocarcinoma (PDAC) in 68 patients (68%), neuroendocrine tumor (NET) in 21 (21%), inflammatory mass/benign lesions in 8 (8%), and pancreatic metastasis in 3 (3%). The final diagnosis was based on definitive histology in 24 cases (23 surgical resections and 1 autopsy), and positive samples at EUS in combination with congruent imaging follow-up in 76 lesions (76%). Eight patients with inflammatory mass/benign lesions did not show any progression or

Table 2a
Ratings for macroscopic visible core (MVC) and histological core according to needle passes.

# pass	Endoscopist rating (MVC)		Pathologist rating (Core)		Agreement			
	% (N)	95% CI	% (N)	95% CI	Concordant% (N)	95% CI	Kappa	95% CI
1	81 (81/100)	72–88	47 (47/100)	37–52	58 (58/100)	48–68	0.19	0.05–0.33
2	82 (81/99)	73–89	57 (56/98)	47–67	58 (57/98)	48–68	0.08	0.00–0.24
3	79 (77/97)	70–87	56 (53/95)	45–66	59 (55/94)	48–68	0.11	0.00–0.28
All	80.7 (239/296)	76.0–85.0	53.2 (156/293)[a]	45.0–61.3	58 (170/292)	52–64	0.12	0.03–0.28

Note: data in parentheses are the actual numbers.
[a] The overall proportion of samples with a core after including the 3/296 (1.0%) missing values (i.e., cases not set to pathology) as a failure to retrieve material was 54.1% (160/296; 95% CI: 48.2–60.4%).

Table 2b
Rating for macroscopic visible core (MCV) and histological core according to per-patient analysis.

# pass	Endoscopist rating (MVC) % (N)	Pathologist rating (Core) % (N)
1	89.0 (81/91)	70.1 (47/67)
2	11.0 (10/91)	25.4 (17/67)
3	2.2 (2/9)	7.5 (3/67)
All	91.0 (91/100) with 95% CI: 83.6–95.8%	67 (67/100), with 95% CI 56.9–76.1%

onset of metastasis during a mean follow-up of 13.4 months (range 12.1–16).

3.1. Presence of a core at pathologist evaluation

Tables 2a and 2b summarize the rates for tissue core at pathologist evaluation.

A total of 296 needle passes was performed. In three of them, no material for histology was acquired and sent to the pathologist, so for the pathologist evaluation a total of 293 samples were considered. One lesion was necrotic, the other two were very small (diameter less than 1 cm) and located in the uncinate process and gave only scanty material that after exsiccation was judged not enough for pathological examination.

Considering all samples obtained (293 samples), the presence of a core was observed in 53.2% of the cases. The presence of a core was found in 47.0% of the samples after the first pass. This value increased to 57.1% (p = 0.044) and to 55.8% (p = 0.049) after the second and third pass, respectively. In 35.5% (104/293) of cases, the specimen obtained was inadequate for histological evaluation but was adequate for cytological evaluation, while no material was retrieved in 11.3% (33/203) (see Fig. S2 Supplemental material).

Per-patient analysis (Table 2a) showed that a core was obtained with 1–3 passes in 67% of the patients. Of these 67 specimens, 70.1% cases were deemed to have a core after the first pass, and in 25.4% a core was obtained with an additional pass. Three cases 7.5% required a third pass before a tissue core was collected.

3.2. Presence of a core at endoscopist evaluation and agreement with pathologist

Considering all needle passes (296 cases), the presence of a core, as intended by the endoscopist, was rated in 80.7% of the cases, with poor agreement with the pathologist interpretation (kappa, 0.12) (see Table 2b). The presence of a core at MOSE was found in 81.0% of the samples after the first pass. This value did not increase significantly after the subsequent two to three passes: second pass, 81.8% (p = 0.850); third pass, 79. 4% (p = 0.720). Logistic regression analysis confirmed that the probability of success at pathologist evaluation was significantly lower than that at MOSE evaluation: 53.2% vs. 80.7% with an OR = 0.27; 95% CI: 0.17–0.44; p < 0.001. Per-patient analysis showed that core was observed with 1–3 passes in 91% (91/100; 95% CI: 83.6–95.8%) at MOSE. Of these 91 cases, 81 (89.0%) were deemed to have a core at the first pass, and in 10/91 (11.0%) a core was obtained with an additional pass. Only two cases (2/91; 2.2%) required a third pass before a core was collected.

Table 4
Sensitivity of EUS for detecting malignancy.

Final diagnosis	N	Sensitivity (%)
PDAC	68	95.6 (65) (87.6–99.1)
NET	21	90.5 (19) (69.6–98.8)
Metastasis from other cancers	3	67.0 (2) (0.90–99.2)
All malignancies	92	93.5 (86.3–97.6)

3.3. Predictors of core presence (or sufficient material for histology/cytology evaluation) at pathologist evaluation

The probability of obtaining a core at pathologist evaluation was examined using logistic regression analysis (Table 3). Patient age (p = 0.165), gender (p = 0.452), mean lesion size (p = 0.725), lesion location (p = 0.580) and the number of needle passes (2 vs. 1, p = 0.286; 3 vs. 1, p = 0.287) were not significant in the univariable analysis. There was however evidence that samples with a worm-like material longer than 1 cm at MOSE were more likely to be classified as "tissue core" by the pathologist compared with a size <1 cm: OR = 2.03. Similarly, those samples classified as "white-yellowish" at MOSE were more likely to represent a core at pathologist evaluation than those classified as "red-brown/mixed": with OR = 2.24; multivariable regression analysis revealed that both color (p = 0.024) and size (p = 0.012) at MOSE were predictive factors for presence of a core at pathologist evaluation (Table 3). Considering samples with sufficient material for histology/cytology versus without any tissue retrieved, samples with a worm-like material longer than 1 cm at MOSE were more likely to be deemed sufficient by the pathologist compared with samples with a size <1 cm with OR = 2.95 (Table 3). However, there was no association between color evaluation at MOSE (white-yellowish vs. red-brown/mixed) and sufficient material for histological or cytological evaluation (OR = 1.46; 95% CI: 0.68–3.14).

3.4. Adequacy of EUS samples for the diagnosis

The final adequacy rate was 93% (Table 4). Of the 93 adequate cases, 77 (82.8%) were deemed sufficient for histology/cytology on the first pass and in 11 (11.8%) cases adequate tissue was obtained with an additional pass. Five cases (5.4%) required a third pass before sufficient tissue for histology or cytology was collected.

Table 3
Results from univariate/multivariable logistic regression analysis for the association between study variables and presence of a core at pathologist evaluation. NE, not entered in the multivariable regression model.

Variable	Sample with a core versus inadequate samples				Sample with sufficient material for histology/ cytology versus without any tissue retrieved			
	Univariable		Multivariable		Univariable		Multivariable	
	ORs [95% CI]	p-Value	ORs [95% CI]	p-Value	ORs [95% CI]	p-Value	ORs [95% CI]	p-Value
Patient age as a continuous variable	1.02 (0.981.05)	0.165	NE		1.00 (0.96–1.04)	0.867	NE	
Gender			NE				NE	
Female	1				1			
Male	0.77 (0.48–1.23)	0.452			1.19 (0.46–3.12)	0.711	NE	
Lesion size as a continuous variable	1.00 (0.97–1.01)	0.725	NE		1.04 (1.00–1.08)	0.054	1.04 (0.98–1.10)	0.154
Lesion Location			NE					
Head	1				1			
Uncinate process	1.29 (0.67–2.48)	0.448			1.54 (0.70–3.61)	0.297		
Neck	0.96 (0.48–1.91)	0.907			0.84 (0.39–1.86)	0.659		
Body	0.80 (0.43–1.47)	0.465			1.60 (0.75–3.64)	0.237		
Tail	0.56 (0.18–1.67)	0.307			1.28 (0.37–5.95)	0.715		
Number of pass			NE				NE	
First	1				1			
Second	1.50 (0.86–2.64)	0.286			1.16 (0.59–2.31)	0.658		
Third	1.42 (0.81–2.51)	0.287			1.42 (0.57–2.22)	0.743		
Size at MOSE								
Size <1 cm at MOSE	1		1		1		1	
Work-like material >1 cm at MOSE	2.03 (1.15–3.54)	0.016	2.03 (1.09-3.81)	0.024	2.95 (1.15–7.54)	0.023	2.95 (1.24–6.97)	0.013
Color at MOSE								
Red-brown/mixed	1				1			
White-yellowish	2.30 (1.23–4.34)	0.01	2.32 (1.14–4.69)	0.012	1.46 (0.68–3.14)	0.336	NE	

Among the 100 lesions, the diagnosis at EUS-biopsy was PDAC in 65 cases, NET in 19, metastasis from other cancers in 2, and benign lesion in 8 cases. The remaining 6 cases were inadequate for histological or cytological evaluation. The follow up confirmed the final in all 8 cases of benign disease (specificity, 100%; 95% CI: 63.1–100%), while in those 6 cases of inadequate biopsy, a diagnosis of malignancy was made (3 PDACs, 2 NETs and 1 metastasis from other cancers) (sensitivity, 93.5%) (see Table 4).

3.5. Adverse events

No severe adverse events (AEs) were recorded. Six procedure-related mild AEs (6%) were observed: 4 mild self-limited bleeding, 1 retroperitoneal hematoma, and 1 GI wall hematoma. All were self-limiting, with no need for blood transfusion. All patients were asymptomatic and did not require hospitalization.

4. Discussion

We performed a prospective multicenter study aimed at evaluating the presence of a histological core using the new 25G fork-tip SharkCore needle for EUS sampling in patients with solid pancreatic mass.

To the best of our knowledge, considering the two previous studies which included 15 [12] and 41 patients [11], this was the first prospective study with a high number of patients (100).

Overall, acquisition of a histological core was achieved in 53.2% of all needle passes and in 67% of patients, according to the pathologist rating. Previous studies on the fork-tip needle [5–7,11,12] reported a percentage of samples sufficient for histological examination ranging from 59% to 95%. The higher values could be explained by several factors, such as a retrospective design or a small sample size. Furthermore, these studies lacked a precise histopathological definition of core. In our study, we underscored the importance of the pathological evaluation in the classification of a histological sample as “core”.

In our study, the small gauge of the needle used can explain the fragmentation of the sample and the consequent lack of “core” at pathological evaluation. We chose the 25G needle for sampling pancreatic masses due to findings of a recent prospective randomized control trial. In this previous study, our group demonstrated the superiority of the 25G needle over the 22G needle in the EUS-FNA of solid masses, and a core specimen was obtained in 44% of cases in which a standard 25G needle was used. In the literature, five meta-analyses compare the diagnostic performance of 22G and 25G needles for sampling solid pancreatic masses, with inconsistent results: two of them suggested that the 25G needle has better diagnostic sensitivity [17,18], but the other three did not observe any difference in performance [19–21]. A recent retrospective paper written by Attili et al. [7], which stated procurement of a histological sample using the SharkCore needle as outcome, demonstrated that the 22G needle was significantly more effective than the 25G in procuring a tissue core biopsy sample.

Interestingly, when combining samples obtained for both histological and cytological analyses, we found a high final adequacy rate of 93%. So, the absence of a core did not affect the diagnostic performance of EUS sampling.

Our results indicated that the evaluation of specimens by the endoscopist using MOSE did not successfully predict the presence of a core as intended by the pathologist. The MOSE carried out by the EUS operator consisted of inspecting the specimen obtained during EUSsampling to determine its adequacy for cytological or histological evaluation. In most cases, the endoscopist concluded that a core was present on the basis of macroscopically recognizable solid components that after processing were seen as fragments, in any case useful for a correct final diagnosis on an adequate specimen. These results may be interpreted as the ability of the endoscopist to understand whether or not a sample is adequate for a final diagnosis that can be cytological or histological. Greater experience or needles with a larger diameter (22G) may be needed to obtain a more reliable and appropriate macroscopic evaluation regarding the presence of a core of a precise dimension.

The MOSE procedure has not been standardized and the evidence on its usefulness to guide the number of needle passes is limited and diverging [22–24]. Because of the lack of robust evidence on the efficacy of MOSE to guide the number of needle passes, the ESGE guidelines [25] do not make recommendations on this issue.

Despite the poor agreement between the endoscopist and the pathologist concerning the presence of a core with such a small caliber needle, a macroscopic evaluation of the specimen in the endoscopic room may have a role suggesting if more needle passes should be required.

Our study also focused on the number of passes in Centers in which ROSE (rapid on site evaluation) was not mandatory. In particular, the third pass added 7.5% to the adequacy for histology and 5.4% to diagnostic adequacy. The literature shows a discrepancy regarding the difference between the minimum number of passes with the SharkCore and with standard FNA needles. Four studies observed a lower number of passes with the SharkCore needle [6,9,10,12], while another one did not show a statistically significant difference [5]. Therefore, in the design phase of the study, we decided to perform 3 needle passes following the European Society of Gastrointestinal Endoscopy (ESGE) guidelines [25]. The ESGE guidelines suggest performing three to four passes with an FNA needle or two to three passes with an FNB needle when on-site cytological evaluation is unavailable.

We experienced 6% of minor complications, the same rate observed in the other prospective study, which reported 5% of minor complications (two self-limiting bleeds during the procedure).

The present study has some limitations. First, the specimens were read by three pathologists (one for each center), with no standardized specimen processing between the centers and without centralization of the reading. Second, in the study were no control group, so a needle comparison was lacking. The latter point could be overcome in a prospective randomized multicenter trial, because of other new core needle are showing very promising results in the procurement rates of histologic cores [26,27].

The strengths of our study are the prospective design with a high patient number and the precise definition of histological core. Moreover, for the first time, the role of MOSE was applied to a new core needle.

In conclusion, the SharkCore needle showed good overall adequacy and a good rate of histological specimens during EUS sampling of solid pancreatic masses, with a minimum number of passes and no major complications. We feel that a similar large prospective study evaluating the performance of the 22G SharkCore needle in core procurement could increase knowledge about these novel types of needle and consequently help to improve daily clinical and endoscopic practice.

Conflict of interest

None declared.

Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.dld.2019.03.025.

References

[1] Kandel P, Wallace MB. Advanced EUS guided tissue acquisition methods for pancreatic cancer. Cancers (Basel) 2018;10.

[2] Wani S, Muthusamy VR, Komanduri S. EUS-guided tissue acquisition: an evidence-based approach (with videos). Gastrointest Endosc 2014;80:939–59, e7.

[3] Nagula S, Pourmand K, Aslanian H, Bucobo JC, Gonda TA, Gonzalez S, et al. Comparison of endoscopic ultrasound-fine-needle aspiration and endoscopic ultrasound-fine-needle biopsy for solid lesions in a multicenter, randomized trial. Clin Gastroenterol Hepatol 2018;16:1307–13, e1.

[4] Cheng B, Zhang Y, Chen Q, Sun B, Deng Z, Shan H, et al. Analysis of fine-needle biopsy vs fine-needle aspiration in diagnosis of pancreatic and abdominal masses: a prospective, multicenter, randomized controlled trial. Clin Gastroenterol Hepatol 2018;16:1314–21.

[5] Jovani M, Abidi WM, Lee LS. Novel fork-tip needles versus standard needles for EUS-guided tissue acquisition from solid masses of the upper GI tract: a matched cohort study. Scand J Gastroenterol 2017;52:784–7.

[6] Kandel P, Tranesh G, Nassar A, Bingham R, Raimondo M, Woodward TA, et al. EUS-guided fine needle biopsy sampling using a novel fork-tip needle: a case-control study. Gastrointest Endosc 2016;84:1034–9.

[7] Attili F, Rimbas M, Fantin A, Fabbri C, Carrara S, Di Maurizio L, et al. Performance of a new histology needle for EUS-guided fine needle biopsy: a retrospective multicenter study. Dig Liver Dis 2018;50:469–74.

[8] DiMaio CJ, Kolb JM, Benias PC, Shah H, Shah S, Haluszka O, et al. Initial experience with a novel EUS-guided core biopsy needle (SharkCore): results of a large North American multicenter study. Endosc Int Open 2016;4:E974–9.

[9] Naveed M, Siddiqui AA, Kowalski TE, Loren DE, Khalid A, Soomro A, et al. A multicenter comparative trial of a novel EUS-guided core biopsy needle (SharkCore) with the 22-gauge needle in patients with solid pancreatic mass lesions. Endosc Ultrasound 2018;7:34–40.

[10] Witt BL, Factor RE, Chadwick BE, Caron J, Siddiqui AA, Adler DG. Evaluation of the SharkCore® needle for EUS-guided core biopsy of pancreatic neuroendocrine tumors. Endosc Ultrasound 2018;7(5):323–8.

[11] Larsen MH, Fristrup CW, Detlefsen S, et al. Prospective evaluation of EUS-guided fine needle biopsy in pancreatic mass lesions. Endosc Int Open 2018;6:E242–8.

[12] Adler DG, Witt B, Chadwick B, Wells J, Taylor LJ, Dimaio C, et al. Pathologic evaluation of a new endoscopic ultrasound needle designed to obtain core tissue samples: a pilot study. Endosc Ultrasound 2016;5:178–83.

[13] Bang JY, Magee SH, Ramesh J, Trevino JM, Varadarajulu S. Randomized trial comparing fanning with standard technique for endoscopic ultrasound-guided fine-needle aspiration of solid pancreatic mass lesions. Endoscopy 2013;45:445–50.

[14] Nakai Y, Isayama H, Chang KJ, Yamamoto N, Hamada T, Uchino R, et al. Slow pull versus suction in endoscopic ultrasound-guided fine-needle aspiration of pancreatic solid masses. Dig Dis Sci 2014;59:1578–85.

[15] Carrara S, Anderloni A, Jovani M, Di Tommaso L, Rahal D, Hassan C, et al. A prospective randomized study comparing 25-G and 22-G needles of a new platform for endoscopic ultrasound-guided fine needle aspiration of solid masses. Dig Liver Dis 2016;48:49–54.

[16] Eloubeidi MA, Gress FG, Savides TJ, Wiersema MJ, Kochman ML, Ahmad NA, et al. Acute pancreatitis after EUS-guided FNA of solid pancreatic masses: a pooled analysis from EUS centers in the United States. Gastrointest Endosc 2004;60:385–9.

[17] Madhoun MF, Wani SB, Rastogi A, Early D, Gaddam S, Tierney WM, et al. The diagnostic accuracy of 22-gauge and 25-gauge needles in endoscopic ultrasound-guided fine needle aspiration of solid pancreatic lesions: a meta-analysis. Endoscopy 2013;45:86–92.

[18] Yang MJ, Yim H, Hwang JC, Lee D, Kim YB, Lim SG, et al. Endoscopic ultrasound-guided sampling of solid pancreatic masses: 22-gauge aspiration versus 25-gauge biopsy needles. BMC Gastroenterol 2015;15:122.

[19] Xu MM, Jia HY, Yan LL, Li SS, Zheng Y. Comparison of two different size needles in endoscopic ultrasound-guided fine-needle aspiration for diagnosing solid pancreatic lesions: a meta-analysis of prospective controlled trials. Medicine (Baltimore) 2017;96:e5802.

[20] Affolter KE, Schmidt RL, Matynia AP, Adler DG, Factor RE. Needle size has only a limited effect on outcomes in EUS-guided fine needle aspiration: a systematic review and meta-analysis. Dig Dis Sci 2013;58:1026–34.

[21] Facciorusso A, Stasi E, Di Maso M, Serviddio G, Ali Hussein MS, Muscatiello N. Endoscopic ultrasound-guided fine needle aspiration of pancreatic lesions with 22 versus 25 gauge needles: a meta-analysis. United Eur Gastroenterol J 2017;5:846–53.

[22] Nguyen YP, Maple JT, Zhang Q, Ylagan LR, Zhai J, Kohlmeier C, et al. Reliability of gross visual assessment of specimen adequacy during EUS-guided FNA of pancreatic masses. Gastrointest Endosc 2009;69:1264–70.

[23] Iwashita T, Nakai Y, Samarasena JB, Park DH, Zhang Z, Gu M, et al. High single-pass diagnostic yield of a new 25-gauge core biopsy needle for EUS-guided FNA biopsy in solid pancreatic lesions. Gastrointest Endosc 2013;77:909–15.

[24] Iwashita T, Yasuda I, Mukai T, Doi S, Nakashima M, Uemura S, et al. Macroscopic on-site quality evaluation of biopsy specimens to improve the diagnostic accuracy during EUS-guided FNA using a 19-gauge needle for solid lesions: a single-center prospective pilot study (MOSE study). Gastrointest Endosc 2015;81:177–85.

[25] Polkowski M, Jenssen C, Kaye P, Carrara S, Deprez P, Gines A, et al. Technical aspects of endoscopic ultrasound (EUS)-guided sampling in gastroenterology: European Society of Gastrointestinal Endoscopy (ESGE) Technical Guideline — March 2017. Endoscopy 2017;49:989–1006.

[26] Park SW, Chung MJ, Lee SH, Lee HS, Lee HJ, Park JY, et al. Prospective study for comparison of endoscopic ultrasound-guided tissue acquisition using 25- and 22-gauge core biopsy needles in solid pancreatic masses. PLoS One 2016;11:e0154401.

[27] Adler DG, Muthusamy VR, Ehrlich DS, Parasher G, Thosani NC, Chen A, et al. A multicenter evaluation of a new EUS core biopsy needle: experience in 200 patients. Endosc Ultrasound 2018.