ORIGINAL ARTICLE

EUS-guided FNA of solid pancreatic masses: a learning curve with 300 consecutive procedures

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Background: The objective of our study was to assess a single operator's learning curve with regard to the number of passes, the diagnostic accuracy, and the complications associated with EUS-guided FNA (EUS-FNA) of solid pancreatic masses.

Methods: The number of passes, the diagnostic accuracy, and the complication rate were prospectively evaluated in 300 consecutive EUS-FNA of solid pancreatic masses performed by a single endosonographer over a 3-year period. The procedures were placed into 3 groups, which contained 100 procedures each. The endosonographer had undergone a third-tier EUS fellowship and had performed 45 supervised pancreatic EUS-FNA during his training.

Results: Of the 300 EUS-FNA performed (median age 63 years, 64% men), no statistically significant differences among the 3 groups with regard to age, gender, race, location, or size of the mass were found. Diagnostic accuracy of the EUS-FNA procedure was similar over time (Group 1, 92%; Group 2, 92%; Group 3, 95%). Median number of passes showed a decreasing trend over the 3-year study period, despite an increasing trend of the number of procedures performed ($r = -0.14$, $p = 0.42$). The median number of passes was lower for Group 2 (median, 3; $p = 0.02$) and Group 3 (median, 3; $p = 0.003$) compared with Group 1 (median, 4). Group 3 (7/100, 7%) was less likely to encounter complications compared with Group 1 (13/100, 13%; $p = 0.24$) and Group 2 (18/100, 18%; $p = 0.03$). Frequency of serious complications was similar across the 3 groups (1%-3%).

Conclusions: With adequate third-tier training, a newly developed EUS program can achieve safe and accurate results of EUS-FNA of the pancreas. The learning curve, however, needs to continue after the fellowship, because more procedures are needed for one to gain proficiency and efficiency with EUS-FNA. (Gastrointest Endosc 2005;61:700-8.)

EUS-guided FNA (EUS-FNA) has emerged as an effective technique for tissue diagnosis in patients with suspected pancreatic cancer.[1-8] Like many procedures, EUS-FNA is thought to be highly operator dependent. In addition, EUS-FNA of solid pancreatic masses is considered by experts as the most challenging of all EUS procedures and might need a longer learning curve to master the technique.[9] Based on expert opinion, the American Society for Gastrointestinal Endoscopy (ASGE) recommends that for a comprehensive competence in all aspects of EUS, at least 150 supervised EUS procedures be performed, with 50 EUS-FNA, and at least 75 procedures should include pancreaticobiliary indications.[10] More specifically, the ASGE guidelines recommend that for pancreatic EUS-FNA competence, the trainee should be competent to perform pancreaticobiliary EUS and should have done at least 25 supervised FNA of pancreatic lesions.[10] More recently, Mertz and Gautam[11] described the learning curve associated with pancreatic cancer diagnosis for a single endosonographer without formal third-tier fellowship training in EUS-FNA. To date, however, there are no published studies that assessed the number of supervised procedures needed to achieve competence with EUS-FNA of solid pancreatic masses. In addition, the performance of newly graduating third-tier fellows compared with expert centers has not been studied. We, therefore, prospectively investigated the performance of a single endosonographer over a 3-year period to assess whether the number performed during a third-tier fellowship was adequate and whether there was a continued learning curve after fellowship with EUS-FNA of solid pancreatic masses. Thus, our objectives were

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to assess the number of passes, the diagnostic accuracy, and the rate of complications encountered in 300 consecutive EUS-FNA procedures.

Capsule Summary

What is already known on this topic

- Endoscopic ultrasound-guided fine needle aspiration (EUS-FNA) is increasingly used for tissue diagnosis of suspected pancreatic cancer.
- EUS-FNA is technically challenging and operator-dependent.
- It is not known how many EUS-FNAs of solid pancreatic masses are needed in order to achieve competence.

What this study adds to our knowledge

- In a prospective trial of a single, third tier–trained, endosonographer, the learning curve for EUS-FNA of solid pancreatic masses continues after fellowship.

PATIENTS AND METHODS

The single endosonographer (M.A.E.) who performed all EUS-FNAs in this study underwent a dedicated third-tier EUS fellowship training. This trainee completed a 3-year GI fellowship where he met all the requirements for general endoscopy training.[12] In addition, he was familiar with the use of the side-viewing duodenoscope (90 ERCPs). A total of 316 EUS procedures were performed during the third-tier (4th year) EUS fellowship, 26% of which included EUS-FNA of various targets lesions. Of the total procedures performed, 226 (72%) examinations were performed for pancreaticobiliary indications of which 45 included EUS-FNA of solid pancreatic masses. As we established the EUS program at the University of Alabama at Birmingham (UAB), we prospectively evaluated EUS-FNA in 300 consecutive procedures with suspected pancreatic cancer over a 3-year period (July 2000 to July 2003). No trainees were involved with or participated in any of the procedures. Patients who required a tissue diagnosis or had failed other attempts by ERCP, CT-guided biopsy, and/or US-guided biopsy were included in this study. The institutional review board of the UAB approved this study. All patients provided written informed consent to undergo the procedure. Patients were placed in the left lateral decubitus position and were sedated with intravenous meperidine, midazolam and/or droperidol according to the judgment of the endoscopist. Standard EUS was performed by using a radial echoendoscope (Olympus GF-UM130; Olympus America Corp, Melville, NY) for evaluating and for staging the pancreatic lesion as previously described.[3] In addition, features of chronic pancreatitis (CP) were recorded.[13] Once a solid focal pancreatic lesion was identified, EUS-FNA then was performed with a curvilinear echoendoscope (UC-30P; Olympus), as previously described.[3] The smears were reviewed immediately by a cytopathologist on site to ensure specimen adequacy. At least 5 passes were obtained from each target lesion unless cytology evaluation performed on site confirmed the presence of malignant cells. We used the final cytology reports in our analysis. The cytologic diagnoses were categorized into the following groups: positive for malignancy; suspicious for malignancy; atypical cells, indeterminate for malignancy; benign/reactive process; or nondiagnostic. Final diagnosis of pancreatic cancer was defined by the following criteria: (1) histologic evidence of pancreatic cancer, and (2) initial malignant cytology with a clinical and/or imaging follow-up that was consistent with the diagnosis of pancreatic cancer, such as death from disease or clinical progression. Lesions were considered benign if there was a lack of progression for at least 6 months in conjunction with continued patient well-being. Criterion standard for classification of disease included the following: surgical resection, death from pancreatic cancer, and repeat radiologic and/or clinical follow-up.

Complications were defined as any deviation from the clinical course after EUS that was associated with the procedure as observed by the endosonographer or the recovery room nurses, or reported by the patients.[3,14,15] Immediate (intraprocedural and in the recovery area) complications were evaluated in all patients. An experienced GI nurse, not involved in the procedure, called patients 24 to 72 hours after the procedure as previously described.[3] Serious adverse events were defined as oversedation that required the administration of a reversal agent, and those events that resulted in a physician or emergency department visit, hospitalization, or death, as previously described.[3,14,15] For the patients who could not be successfully contacted, information was collected from the medical records and clinic follow-up.

STATISTICAL ANALYSIS

We analyzed 300 consecutive EUS-FNA procedures (282 patients) performed over a 3-year period (July 2000 to July 2003). Each procedure was regarded as a separate data point. The procedures were placed into 3 groups, each containing 100 procedures. Continuous variables were reported as means (with standard deviation) and medians (with range). Initially, the groups were compared with each other to examine differences related to patient characteristics, pancreatic mass characteristics, and other factors. The comparison was performed by using the chi-square test for proportions or the Kruskal-Wallis test for continuous data when the data were not normally distributed. The outcome of interest was the EUS-FNA associated number of passes. The outcome was reported as a continuous, as well as a categorized variable (5 vs. 1 to

4 passes, reference category). We compared the medians of the 3 groups with each other by using the Mann-Whitney-Wilcoxon test, while, for the dichotomized outcome, crude odds ratio (OR) with exact 95% confidence intervals (CI) (with the Fisher 2-tailed exact p value) were reported. We used the Bonferroni correction for multiple comparisons when the 3 groups were compared for median number of passes. The Mantel-Haenszel (MH) chi-square test was used to examine the dichotomized outcome data for trend.

For univariate analysis that examined the association between the dichotomized outcome and independent factors, we calculated crude OR with exact 95% CI, with a corresponding Fisher 2-tailed exact test p values. The ORs reported in the study are crude unless specified as ''adjusted,'' meaning that they arise from multivariable logistic regression analysis by measuring the independent effects of factors adjusted for the contributions of each of the other factors. Factors with $p \leq 0.25$ in univariate analysis were selected to construct logistic regression models.

Statistical significance was set at 0.05. The analysis was conducted with SAS statistical software (version 6.12) (SAS Institute Inc, Cary, NC).

RESULTS

General characteristics

Mean age of the patients was 62.6 years (SD 11.7 years), with a median of 63 years (range 33-89 years). Most of the patients were men (64%) and white (74%). There were no statistically significant differences among the 3 groups with regard to age, gender, and race.

Clinical presentation, investigations, and characteristics of mass lesions

Abdominal pain (68%), loss of weight (77%), jaundice (44%), acute pancreatitis (10%), or early satiety (8%) were some of the common symptoms of presentation. EUS procedure reported changes of CP in 25% (75/300) of the patients (Table 1). Prior tissue diagnosis was attempted in 118 patients (39%), where ERCP was the most common (94/118) prior investigation. Malignant pathology was obtained in 66% (194/296) of the masses on FNA reading, whereas 25% (74/296) had benign and 9% (28/296) had suspicious/atypical FNA cytology. (Tables 1 and 2) Four procedures were inconclusive for a diagnosis (''failed'' or ''inadequate''). Most of the malignant masses were primary adenocarcinomas (210/293, 72%), whereas 6% (19/293) were other types of cancers (neuroendocrine, 13; metastatic renal cell carcinoma, 3; metastatic melanoma, 1; malignant fibrous histiocytoma, 1; lymphoma, 1). (Table 1) The remaining 22% (64/293) had benign mass or CP confirmed on long-term follow-up. We could not determine (''indeterminate'') the final diagnosis in 4 patients (initial FNA being benign in two, suspicious/atypical in the other two), whereas 3 patients were lost to follow-up (initial FNA being benign).

We did not find significant differences between the 3 groups with regard to prior tissue diagnosis attempt, presentation with acute pancreatitis, mass location, size of the tumor, EUS findings of CP, FNA reading, or type of cancer (adenocarcinoma vs. other types) (Table 1).

Accuracy and complication assessment

To determine the accuracy of diagnosis, our criterion standard for classification of disease included the following: surgical resection (n = 85), death from pancreatic cancer (n = 83), and clinical follow-up (n = 129); 3 patients were lost to follow-up. The median follow-up for all patients (n = 296) was 233 days (interquartile range [IQR], 97-412); in addition to those lost to follow-up patients (n = 3), date of death was unknown in one. All of the benign lesions by EUS-FNA had clinical follow-up >180 days, with a median of 418 days (IQR = 278.5-548 days). Patients lost to follow-up (n = 3) and indeterminate final diagnosis (n = 4) were excluded for calculating accuracy. A mass with ''suspicious/atypical'' (or malignant) FNA reading with final diagnosis of benign mass was considered ''false positive,'' while failed procedures with final diagnosis as ''malignant'' were regarded as ''false negative.'' Patients with atypical and suspicious cytology were considered true positive if the final diagnosis was malignancy. Diagnostic accuracy of the EUS-FNA procedure in detecting malignant (true positive) and benign (true negative) lesions were similar over the period (Group 1, 92%; Group 2, 92%; Group 3, 95%); overall accuracy being 93% (Table 2).

For complications, 194 (64.6%) patients were followed by phone, and 104 (34.7%) clinically (at UAB); two (0.6%) could not be contacted. In total, 13% (38/300) patients had complications (minor and/or major). Of the 38 patients, 6 (16%) had major complications that required hospitalization or emergency department visit, while the remaining (32/38, 84%) had minor complications. Major complications included pancreatitis (n = 1), severe abdominal pain (n = 2), fever (n = 2), hypoxia from oversedation (n = 1). Minor complications included mild abdominal pain, distension, nausea, vomiting, diarrhea, or minor bleeding at the biopsy site (not clinically manifested). No perforations were encountered. The overall acute pancreatitis incidence was 0.33% (1/300): 95% CI[0.01, 1.84]. Overall, 13 (13%) of the Group 1, 18 (18%) of the Group 2, and 7 (7%) of the Group 3 patients had complications. Proportion of minor complications in Group 1 was 12%, in Group 2 was 16%, and in Group 3 was 4%. Group 3 was less likely to encounter minor complication compared with Group 1 ($p = 0.07$) and Group 2 ($p = 0.004$), while no significant difference was found between Group 1 and Group 2 ($p = 0.42$). The difference remained significant between Group 3 and

TABLE 1. Pancreatic mass and other characteristics among the 3 groups

	Group 1 N = 100	Group 2 N = 100	Group 3 N = 100	Total N = 100
Characteristic	**N (%)**	**N (%)**	**N (%)**	**N (%)**
Presentation with acute pancreatitis				
Yes	11 (11%)	12 (12%)	7 (7%)	30 (10%)
No	89 (89%)	88 (88%)	93 (93%)	270 (90%)
p Value		0.46*		—
Prior CT done				
Yes	89 (89%)	77 (77%)	79 (79%)	245 (82%)
No	11 (11%)	23 (23%)	21 (21%)	55 (18%)
p Value		0.06*		—
Prior tissue diagnosis attempt				
Yes	46 (46%)	35 (35%)	37 (37%)	118 (39%)
No	54 (54%)	65 (65%)	63 (63%)	182 (61%)
p Value		0.24*		—
Mass location				
Head	65 (65%)	69 (69%)	63 (63%)	197 (66%)
Other	35 (35%)	31 (31%)	37 (37%)	103 (34%)
p Value		0.66*		—
Largest diameter (mm)				
Range	17-70	7-62	19-95	7-95
Mean (SD)	32.8 (8.4)	32.2 (11.6)	35.4 (11.7)	33.5 (10.7)
Median	32.0	30.0	34.0	32.0
p Value		0.17†		—
EUS finding of CP				
Yes	25 (32%)	26 (28%)	24 (25%)	75 (25%)
No	75 (68%)	74 (72%)	76 (75%)	215 (75%)
p Value		0.95*		—
FNA reading (initial)				
Benign	25 (26%)	29 (29%)	20 (20%)	74 (25%)
Malignant	61 (62%)	63 (64%)	70 (71%)	194 (66%)
Suspicious/atypical	12 (12%)	7 (7%)	9 (9%)	28 (9%)
Inconclusive‡	2	1	1	4
p Value		0.45*		—
Final diagnosis§				
Benign mass/CP	20 (20%)	24 (24%)	20 (21%)	64 (22%)
Adenocarcinoma	74 (75%)	63 (64%)	73 (75%)	210 (72%)

(continued)

TABLE 1. (continued)

Characteristic	Group 1 N = 100 N (%)	Group 2 N = 100 N (%)	Group 3 N = 100 N (%)	Total N = 100 N (%)
Other‖	5 (5%)	10 (10%)	4 (4%)	19 (6%)
p Value		0.31*		—

SD, Standard deviation; *CP,* chronic pancreatitis.
*Chi-square test for proportions.
†Kruskal-Wallis test.
‡"Failed" (n = 3) and "inadequate for tissue diagnosis" (n = 1) procedures excluded; the category is not included in calculating *p*.
§Lost to follow-up (n = 3) patients and "indeterminate" lesions (n = 4) excluded.
‖Includes neuroendocrine (n = 13), metastatic tumors (n = 4), malignant fibrous histiocytoma (n = 1), and lymphoma (n = 1).

TABLE 2. Initial cytopathology and final diagnosis of 300 procedures

EUS-guided FNA cytology	Final diagnosis Benign	Malignant	Indeterminate/unknown	Total
Benign	58	11	5	74
Atypical	5	9	1	15
Suspicious	—	12	1	13
Malignant	1	193	—	194
Failed/inadequate	—	4	—	4
Total	64	229	7	300

CI, Confidence interval.
Overall accuracy, 92.8%: 95% CI[9.6, 94.9].

Group 2 when adjusted for multiple comparisons ($p = 0.01$). Frequency of serious complications was similar across the 3 groups (Group 1, 1%; Group 2, 2%; and Group 3, 3%; $p = 0.62$).

Number of EUS-FNA passes

The majority (68%) of procedures required 4 or less passes for tissue diagnosis. Median number of passes showed a decreasing trend over the 3-year study period, despite an increasing trend of the number of procedures performed ($r = -0.14$, $p = 0.42$) (Fig. 1). When the median number of passes was compared among the 3 groups, a statistically significant difference was observed for Group 1 vs. Group 3 (median 4 vs. 3, $p = 0.009$) but not for Group 2 vs. Group 3 ($p = 0.06$), when the Bonferroni correction for p value was applied (Fig. 2).

The proportion of procedures that required 4 or less passes increased from 60% in Group 1 to 68% in Group 2 to 77% in Group 3 (MH chi-square trend, 6.71; $p = 0.01$). Both Groups 2 and 3 were less likely to require ≥ 5 passes compared with Group 1; the difference was not statistically significant for Group 2 (OR 0.7: exact 95% CI[0.4, 1.3], $p = 0.30$), while significant difference was observed for Group 3 (OR 0.4: exact 95% CI[0.2, 0.9]; $p = 0.01$) compared with Group 1.

Predictors of number of passes

Univariate analysis. Univariate analysis showed that malignant masses were significantly less likely to require ≥ 5 passes compared with benign masses (OR 0.2: 95% CI[0.1, 0.4]) (Table 3). In addition, patients with changes of CP were significantly more likely to have ≥ 5 passes compared with those without CP (OR 3.3: 95% CI[1.8, 5.8]). We did not find statistically significant results for other variables in the univariate analysis. (Table 3) The factors (gender; EUS finding of CP; prior attempt at tissue diagnosis; and initial FNA reading), with $p \leq 0.25$ were selected for logistic regression modeling.

Multivariable analysis. We conducted logistic regression procedures to determine differences in the odds of having ≥ 5 vs. 1 to 4 (reference) passes between Groups 2 and 1, and Groups 3 and 1 (Table 3). By adjusting for other factors in the model, Group 2 and Group 3 were less likely to require ≥ 5 passes compared

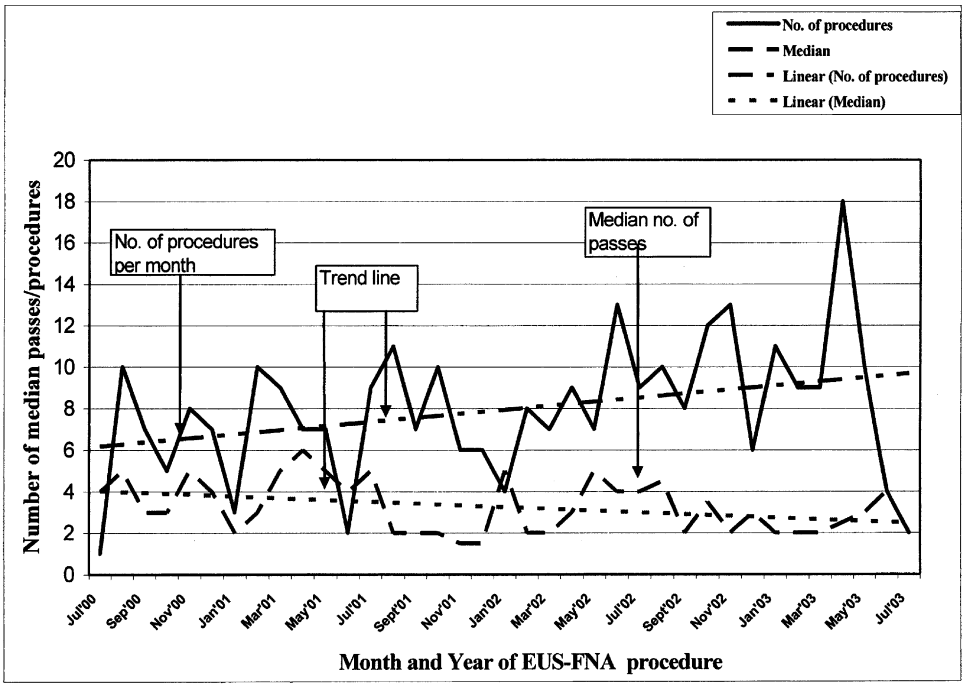
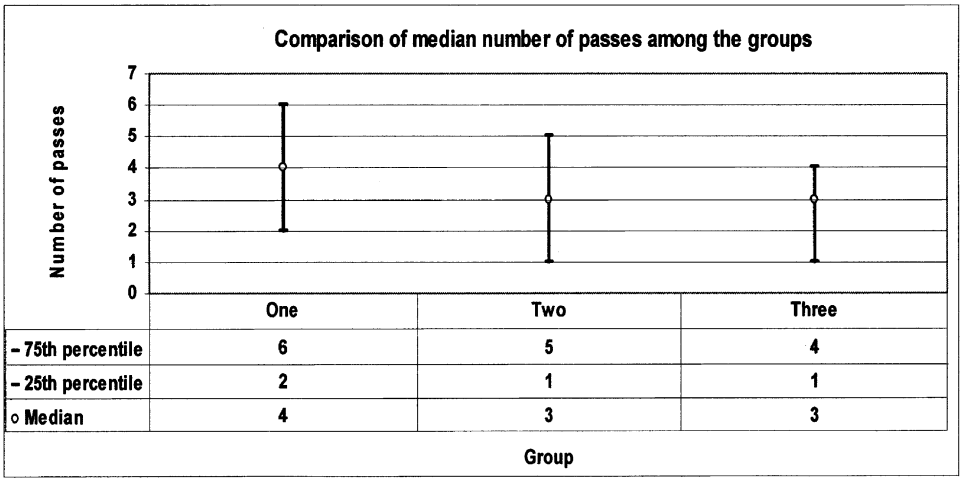


Figure 1. Correlation between median number of passes and procedures by each month, July 2000 to July 2003 ($r = -0.14$; $p = 0.42$).



	One	Two	Three
– 75th percentile	6	5	4
– 25th percentile	2	1	1
○ Median	4	3	3

Figure 2. Comparison of median number of passes among the 3 groups. (Kruskal-Wallis test, $p = 0.01$. Mann-Whitney-Wilcoxon test: Groups 1 vs. 2, $p = 0.02$; Groups 1 vs. 3, $p = 0.003$; Groups 2 vs. 3, $p = 0.57$.)

with Group 1 (Table 3). The difference between Groups 2 and 1 was not statistically significant, while the difference between Groups 3 and 1 was statistically significant. In addition, patients with malignant masses were significantly less likely to require ≥ 5 passes ($p < 0.001$). Patients with a prior tissue diagnosis attempt, however, were significantly more likely to require ≥ 5 passes ($p = 0.04$).

A final logistic regression model also was constructed by using the "true" (final) state of pathology (either benign or malignant), replacing the initial FNA reading in the model to examine whether the association remained constant (model not presented). When adjusted for the other factors, Group 2 ($p = 0.29$) and Group 3 ($p = 0.01$) were less likely to require ≥ 5 passes compared with Group 1. The presence of CP required ≥ 5 passes (adjusted OR 2.7: 95% CI[1.3, 5.8], $p = 0.01$), while malignant masses were less likely to require ≥ 5 passes compared with benign masses (adjusted OR 0.7: 95% CI[0.4, 1.3], $p = 0.37$).

TABLE 3. Crude and adjusted ORs and 95% CI for association between number of passes (≥5 vs. 1 to 4*) and predicting factors

	Univariate analysis		Logistic regression model N = 295	
Predicting factor	**Crude OR (exact 95% CI)**	***p***	**Adjusted OR (95% CI)**	***p***
Group				
2 vs. 1*	0.7 (0.4, 1.3)	0.30	0.7 (0.4, 1.4)	0.36
3 vs. 1*	0.4 (0.2, 0.9)†	0.01†	0.5 (0.3, 0.9)†	0.03†
Gender				
Men vs. women*	1.7 (1.0, 2.9)	0.07	1.3 (0.7, 2.4)	0.40
Prior tissue diagnosis attempt				
Yes vs. no*	1.5 (0.9, 2.6)	0.12	1.8 (1.0, 3.1)†	0.04†
EUS finding of CP[b]				
Yes vs. no*	3.3 (1.8, 5.8)†	<0.001†	1.6 (0.7, 3.3)	0.24
FNA reading				
Malignant vs. benign*	0.2 (0.1, 0.4)†	<0.001†	0.3 (0.1, 0.6)†	<0.001†
Susp./Atyp vs. benign*	1.0 (0.4, 2.6)	1.00	1.1 (0.4, 2.9)	0.81

OR, Odds ratio; *CI,* confidence interval; *CP,* chronic pancreatitis.
Note: Adjusted ORs calculated by using multiple logistic regression analysis; failed (n=3) procedures, 'unknown' number passes (n=1), and 'inadequate for tissue diagnosis' procedure (n=1) were excluded from the model.
*Referent category.
†Statistically significant.

DISCUSSION

EUS is recognized as an advanced procedure with a difficult and a prolonged learning curve.[9] There is no objective data on which the GI societies or training programs may base credentialing requirements.[10] When little or no data exist from well-designed prospective trials, emphasis is given to results from large series and reports from recognized experts or personal experiences. In addition, EUS-FNA of solid pancreatic masses are considered by experts to be the most challenging of all EUS procedures, and trainees might need a long learning curve to master the technique.[9] Based on expert opinion, the ASGE recommends that for a comprehensive competence in all aspects of EUS, at least 150 supervised EUS procedures be performed, with 50 EUS-FNA, and at least 75 procedures should include pancreaticobiliary indications.[10] More specifically, the ASGE guidelines recommend that for pancreatic EUS-FNA competence, the trainee should be competent to perform pancreaticobiliary EUS and to have done at least 25 supervised FNA of pancreatic lesions.[10]

The results of this study suggest that after adequate third-tier supervised training, a newly developed program can provide results similar to those of well-established EUS centers.[16] In addition, this study shows that a long learning curve exists for EUS-FNA of solid pancreatic masses. While 25 EUS-FNA procedures might be adequate as a start, this number is considered the threshold after which competence can be assessed. For instance, while the accuracy reported in this study for the first 100 procedures parallels results from expert centers, it is clear that the number of passes and complications were higher for the first group compared with the third group. Group 2 and Group 3 were not different in terms of number of passes required. Although fewer complications were encountered with Group 3 compared with Group 2 (but not Group 1), the frequency of serious complications remained similar across all 3 time periods. This suggests that about 150 EUS-FNAs of the pancreas might be needed to become very proficient and facile in sampling solid masses of the pancreas.

The number of passes needed to achieve adequate samples and to diagnose malignancy decreased over time in this study, reflecting improved efficiency of the EUS-FNA procedure over time. While we did not record the duration of each EUS-FNA procedure, even a decrease by one FNA pass is associated with a reduction in procedure time by 10 to 15 minutes, which is clinically relevant and important. This increased efficiency of the procedure can be explained by several factors: (a) better identification, recognition, and targeting of the lesions by the endosonographer; (b) earlier or better recognition of the cancer by the attending cytopathologist, thus necessitating fewer passes over the course of the study. We acknowledge that there was no upgrade of the equipment nor any change of the type of needles used over time. Thus,

it appears that there is a steep learning curve involved in the process of EUS-FNA of solid pancreatic masses.

We found that the location of the mass and its size did not affect the number of passes. We noted that the presence of pancreatitis as detected by EUS and a prior attempt at biopsy make a mass possibly more difficult to diagnose. This can be partly explained by the desmoplastic reaction caused by the tumor, as well as the inherent difficulty in diagnosing pancreatic cancer in the context of pancreatitis. Similarly, a previous study[17] has shown that the sensitivity for EUS-FNA of solid pancreatic masses decreased in the context of chronic pancreatitis.

Our findings of the presence of a leaning curve for EUS-FNA of solid pancreatic masses is supported by the literature on learning with EUS in general, therapeutic endoscopy, and routine endoscopy. In one multicenter prospective study of training in EUS, the competence of fellows at two tertiary, referral medical centers was studied.[18] That study suggests that at least 150 supervised procedures are needed for trainees to independently perform and interpret EUS examinations. While the easiest indications for EUS are considered esophageal- and rectal-cancer staging, it is clear from that study that the learning curve is even longer for the adequate study of the pancreas, including the appropriate identification of the ampulla. The number needed to assess competence for EUS-FNA was not assessed in that multicenter study.[18] A survey of the American Endosonography Club found that while technical competence in pancreaticobiliary imaging could be achieved in 94 cases, interpretive competence required 121 procedures.[19] Gress et al[20] found that EUS staging accuracy for pancreatic cancer improved after 100 cases, thus suggesting a correlation between the accuracy of EUS staging and the number of procedures performed. Most cases of understaging and overstaging occurred in the first 100 procedures compared with the later cohort.[20] Fockens et al[21] found that adequate staging accuracy in patients with esophageal cancer was achieved only after 100 examinations. Schlick et al[22] similarly found that reliable staging for cancer of the esophagus and of the cardia can be obtained only after 75 examinations have been performed. Carmody and Otchy[23] found that accuracy of transrectal US staging improved with time and experience with the procedure. Similarly, Mertz and Gautam[11] also have shown that the accuracy of EUS-FNA improved after 50 unsupervised EUS-FNA procedures of the pancreas.

We note the limitations of this study. These data represent a personal and a unique experience in a busy academic program of a single endosonographer who has a large referral base for patients with suspected pancreatic cancer. In addition, the number of patients provided during advanced fellowship training was high, which allowed exposure to a wide variety of EUS and EUS-FNA cases. Therefore, this data may not be extrapolated to individuals attempting to train themselves or to programs that have a low volume of procedures. However, one concludes that the number of pancreatic EUS-FNA performed during the third-tier fellowship was probably adequate for this endosonographer to start practicing this procedure on his own. Moreover, the accuracy of EUS-FNA for pancreatic cancer did not change significantly over the course of the study and was comparable with expert centers, suggesting that ''most'' learning occurred during the mentored cases during the fellowship. In contrast, a self-teaching system could result in producing an experienced endosonographer; this could, however, be at the expense of low accuracy in the first 50 to 100 procedures.[11] Mertz and Gautam[11] reported a sensitivity ranging from 40% to 80% in their first 50 cases, values much lower than results of this study or those of expert EUS centers.[3,7,16] The clear message that we learned from that study is that through persistence, dedication, and self-instruction, with some supervised mentorship, EUS-FNA proficiency can be met after the basic EUS skills has been acquired.[9,11]

It is generally accepted that there is a very wide range in the number of procedures required for different fellows to be considered competent in EUS. Cass et al[24] found that there was substantial variation in the rate of skill acquisition between individual trainees when they evaluated gastroenterology fellows at 14 institutions. While ''fast learners'' could achieve competence in performing EGD after 50 procedures, the average fellow needed more than 160 diagnostic EGD to achieve competence. Unlike other endoscopy procedures, EUS includes not just endoscopy but also interpretation of real-time radiologic images. A substantial individual variation can be expected among learners before this procedure can be mastered.

In summary, it appears that the recommended number of 25 procedures may not be an adequate threshold for training in EUS-FNA of the pancreas based on this single individual's experience. This study suggests that even after performing 45 of these examinations during a third-tier fellowship, more procedures are needed for one to gain proficiency and efficiency with EUS-FNA. Our results could be used by professional societies to direct their training guidelines, credentialing, and granting privileges for EUS-FNA of the pancreas.

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REFERENCES

1. Bhutani MS, Hawes RH, Baron PL, Sanders-Cliette A, Van Velse A, Osborne JF, et al. Endoscopic ultrasound guided fine needle aspiration of malignant pancreatic lesions. Endoscopy 1997;29:854-8.

2. Chang KJ, Nguyen P, Erickson RA, Durbin TE, Katz KD. The clinical utility of endoscopic ultrasound-guided fine-needle aspiration in the diagnosis and staging of pancreatic carcinoma. Gastrointest Endosc 1997;45:387-93.
3. Eloubeidi MA, Chen VK, Eltoum IA, Jhala D, Chhieng DC, Jhala N, et al. Endoscopic ultrasound-guided fine needle aspiration biopsy of patients with suspected pancreatic cancer: diagnostic accuracy and acute and 30-day complications. Am J Gastroenterol 2003;98:2663-8.
4. Erickson RA, Sayage-Rabie L, Beissner RS. Factors predicting the number of EUS-guided fine-needle passes for diagnosis of pancreatic malignancies. Gastrointest Endosc 2000;51:184-90.
5. Faigel DO, Ginsberg GG, Bentz JS, Gupta PK, Smith DB, Kochman ML. Endoscopic ultrasound-guided real-time fine-needle aspiration biopsy of the pancreas in cancer patients with pancreatic lesions. J Clin Oncol 1997;15:1439-43.
6. Gress F, Gottlieb K, Sherman S, Lehman G. Endoscopic ultrasonography-guided fine-needle aspiration biopsy of suspected pancreatic cancer. Ann Intern Med 2001;134:459-64.
7. Harewood GC, Wiersema MJ. Endosonography-guided fine needle aspiration biopsy in the evaluation of pancreatic masses. Am J Gastroenterol 2002;97:1386-91.
8. Voss M, Hammel P, Molas G, Palazzo L, Dancour A, O'Toole D, et al. Value of endoscopic ultrasound guided fine needle aspiration biopsy in the diagnosis of solid pancreatic masses. Gut 2000;46:244-9.
9. Chang KJ. EUS-guided FNA: the training is moving. Gastrointest Endosc 2004;59:69-73.
10. Eisen GM, Dominitz JA, Faigel DO, Goldstein JA, Petersen BT, Raddawi HM, et al. Guidelines for credentialing and granting privileges for endoscopic ultrasound. Gastrointest Endosc 2001;54:811-4.
11. Mertz HG, Gautam S. The learning curve for EUS-guided FNA of pancreatic cancer. Gastrointest Endosc 2004;59:33-7.
12. Eisen GM, Dominitz JA, Faigel DO, Goldstein JL, Kalloo AN, Petersen BT, et al. Guidelines for advanced endoscopic training. Gastrointest Endosc 2001;53:846-8.
13. Sahai AV, Zimmerman M, Aabakken L, Tarnasky PR, Cunningham JT, Van Velse A, et al. Prospective assessment of the ability of endoscopic ultrasound to diagnose, exclude, or establish the severity of chronic pancreatitis found by endoscopic retrograde cholangiopancreatography. Gastrointest Endosc 1998;48:18-25.
14. Zubarik R, Fleischer DE, Mastropietro C, Lopez J, Carroll J, Benjamin S, et al. Prospective analysis of complications 30 days after outpatient colonoscopy. Gastrointest Endosc 1999;50:322-8.
15. Zubarik R, Eisen G, Mastropietro C, Lopez J, Carroll J, Benjamin S, et al. Prospective analysis of complications 30 days after outpatient upper endoscopy. Am J Gastroenterol 1999;94:1539-45.
16. Wiersema MJ, Vilmann P, Giovannini M, Chang KJ, Wiersema LM. Endosonography-guided fine-needle aspiration biopsy: diagnostic accuracy and complication assessment. Gastroenterology 1997;112:1087-95.
17. Fritscher-Ravens A, Brand L, Knofel WT, Bobrowski C, Topalidis T, Thonke F, et al. Comparison of endoscopic ultrasound-guided fine needle aspiration for focal pancreatic lesions in patients with normal parenchyma and chronic pancreatitis. Am J Gastroenterol 2002;97:2768-75.
18. Hoffman BJ, Wallace MB, Eloubeidi MA, Sahai AV, Chak A, Van Velse A, et al. How many supervised procedures does it take to become competent in EUS? Results of a multicenter three-year study [abstract]. Gastrointest Endosc 2000;51:AB139.
19. Hoffman BJ, Hawes RH. Endoscopic ultrasound and clinical competence. Gastrointest Endosc Clin N Am 1995;5:879-84.
20. Gress FG, Hawes RH, Savides TJ, Ikenberry SO, Cummings O, Kopecky K, et al. Role of EUS in the preoperative staging of pancreatic cancer: a large single-center experience. Gastrointest Endosc 1999;50:786-91.
21. Fockens P, Van den Brande JH, van Dullemen HM, van Lanschot JJ, Tytgat GN. Endosonographic T-staging of esophageal carcinoma: a learning curve. Gastrointest Endosc 1996;44:58-62.
22. Schlick T, Heintz A, Junginger T. The examiner's learning effect and its influence on the quality of endoscopic ultrasonography in carcinoma of the esophagus and gastric cardia. Surg Endosc 1999;13:894-8.
23. Carmody BJ, Otchy DP. Learning curve of transrectal ultrasound. Dis Colon Rectum 2000;43:193-7.
24. Cass OW, Freeman ML, Peine CJ, Zera RT, Onstad GR. Objective evaluation of endoscopy skills during training. Ann Int Med 1993;118:40-4.

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