Quality indicators for EUS

EUS has become integral to the diagnosis and staging of GI and mediastinal mass lesions and conditions. EUS-guided FNA (EUS-FNA) allows the endoscopist to obtain tissue or fluid for cytologic and chemical analysis, adding to the procedure's utility. Furthermore, the recent development of EUS-guided core biopsy techniques enables histologic sampling in selected cases and for obtaining tissue for molecular analysis in neoadjuvant and palliative settings. The clinical effectiveness of EUS and EUS-FNA depends on the judicious use of these techniques.

The quality of health care can be measured by comparing the performance of an individual or a group of individuals with an ideal or benchmark.[1] The particular parameter that is being used for comparison is termed a quality indicator. Quality indicators often are reported as ratios between the incidence of correct performance and the opportunity for correct performance or as the proportion of interventions that achieve a predefined goal.[2] Quality indicators can be divided into 3 categories: (1) structural measures—these assess characteristics of the entire health care environment (eg, availability and maintenance of endoscopy equipment at a hospital), (2) process measures—these assess performance during the delivery of care (eg, diagnostic rates of malignancy in patients undergoing EUS-FNA of pancreatic masses), (3) outcome measures: these assess the results of the care that was provided (eg, frequency of infection after EUS with FNA of cystic lesions).

METHODOLOGY

In 2006, the American Society for Gastrointestinal Endoscopy (ASGE)/American College of Gastroenterology (ACG) Task Force on Quality in Endoscopy published the first version of quality indicators for EUS.[3] The present update integrates new data pertaining to previously proposed quality indicators and new quality indicators for performing EUS. We prioritized indicators that had wide-ranging clinical application, were associated with variation in practice and outcomes, and were validated in clinical studies. Clinical studies were identified through a computerized search of Medline followed by review of the bibliographies of all relevant articles. When such studies were absent, indicators were chosen by expert consensus. Although feasibility of measurement was a consideration, we hope that inclusion of highly relevant, but not yet easily measurable, indicators will promote their eventual adoption. Although a comprehensive list of quality indicators is proposed, we recognize that, ultimately, only a small subset might be widely used for continuous quality improvement, benchmarking, or quality reporting. As in 2006, current the task force concentrated its attention on parameters related solely to endoscopic procedures. Although the quality of care delivered to patients is clearly influenced by many factors related to the facilities in which endoscopy is performed, characterization of unit-related quality indicators was not included in the scope of this effort.

The resultant quality indicators were graded on the strength of the supporting evidence (Table 1). Each quality indicator was classified as an outcome or a process measure. Although outcome quality indicators are preferred, some can be difficult to measure in routine clinical practice, because they need analysis of large amounts of data and long-term follow-up and may be confounded by other factors. In such cases, the task force deemed it reasonable to use process indicators as surrogate measures of high-quality endoscopy. The relative value of a process indicator hinges on the evidence that supports its association with a clinically relevant outcome, and such process measures were emphasized.

The quality indicators for this update were written in a manner that lends them to be developed as measures. Although they remain quality indicators and not measures, this document also contains a list of performance targets for each quality indicator. The task force selected performance targets from benchmarking data in the literature when available. When no data were available to support establishing a performance target level, "N/A" (not available) was listed. However, when expert consensus considers failure to perform a given indicator a "never event," such as monitoring vital signs during sedation, then the performance target was listed as >98%. It is important to emphasize that the performance targets listed do not necessarily reflect the standard of care but rather serve as specific goals to direct quality improvement efforts.

Quality indicators were divided into 3 time periods: preprocedure, intraprocedure, and postprocedure. For each category, key relevant research questions were identified.

In order to guide continuous quality improvement efforts, the task force also recommended a high-priority subset of the indicators described, based on their clinical relevance and importance, evidence that performance

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TABLE 1. Grades of recommendation*

Grade of recommendation	Clarity of benefit	Methodologic strength supporting evidence	Implications
1A	Clear	Randomized trials without important limitations	Strong recommendation; can be applied to most clinical settings
1B	Clear	Randomized trials with important limitations (inconsistent results, nonfatal methodologic flaws)	Strong recommendation; likely to apply to most practice settings
1C+	Clear	Overwhelming evidence from observational studies	Strong recommendation; can apply to most practice settings in most situations
1C	Clear	Observational studies	Intermediate-strength recommendation; may change when stronger evidence is available
2A	Unclear	Randomized trials without important limitations	Intermediate-strength recommendation; best action may differ depending on circumstances or patients' or societal values
2B	Unclear	Randomized trials with important limitations (inconsistent results, nonfatal methodologic flaws)	Weak recommendation; alternative approaches may be better under some circumstances
2C	Unclear	Observational studies	Very weak recommendation; alternative approaches likely to be better under some circumstances
3	Unclear	Expert opinion only	Weak recommendation; likely to change as data become available

*Adapted from Guyatt G, Sinclair J, Cook D, et al. Moving from evidence to action. Grading recommendations—a qualitative approach. In: Guyatt G, Rennie D, editors. Users' guides to the medical literature. Chicago: AMA Press; 2002. p. 599-608.

varies significantly in clinical practice, and feasibility of measurement (a function of the number of procedures needed to obtain an accurate measurement with narrow confidence intervals [CI] and the ease of measurement). A useful approach for individual endoscopists is to first measure their performance with regard to these priority indicators. Quality improvement efforts would then move to different quality indicators if endoscopists are performing above recommended thresholds, or the employer and/or teaching center could institute corrective measures and remeasure performance of low-level performers.

Recognizing that certain quality indicators are common to all GI endoscopic procedures, such items are presented in detail in a separate document, similar to the process in 2006.[4] The preprocedure, intraprocedure, and postprocedure indicators common to all endoscopy are listed in Table 2. Those common factors will be discussed in this document only insofar as the discussion needs to be modified specifically related to EUS.

Preprocedure quality indicators

The preprocedure period includes all contact between members of the endoscopy team with the patient before the administration of sedation. Common issues for all endoscopic procedures during this period include: appropriate indication, informed consent, risk assessment, formulation of a sedation plan, clinical decision making with regard to prophylactic antibiotics and management of antithrombotic drugs, and timeliness of the procedure.[5] Preprocedure quality indicators specific to performance of EUS include the following:

1. *Frequency with which EUS is performed for an indication that is included in a published standard list of appropriate indications, and the indication is documented*

   Level of evidence: 1C

   Performance target: >80%

   Type of measure: process

   The ASGE has published appropriate indications for EUS (Table 3).[6] An appropriate indication should be documented for each procedure, and, when it is not a standard indication listed in the current ASGE Appropriate Use of GI Endoscopy guideline, it should be justified in the documentation.

   Discussion: Acceptable indications for EUS have been published recently.[6,7] Although there are many instances in which EUS can be performed, the value of the procedure in the care of any particular patient depends on its impact on management, improvement in outcomes, and the superiority of EUS over other available imaging or surgical procedures. This implies a certain degree of clinical judgment in choosing when and if to perform EUS in relation to other procedures, making rigid indications impractical. Expert opinion

TABLE 2. Summary of proposed quality indicators common to all endoscopic procedures[a,2]

Quality indicator	Grade of recommendation	Measure type	Performance target (%)
Preprocedure			
1. Frequency with which endoscopy is performed for an indication that is included in a published standard list of appropriate indications, and the indication is documented	1C+	Process	>80
2. Frequency with which informed consent is obtained and fully documented	3	Process	>98
3. Frequency with which preprocedure history and directed physical examination are performed and documented	3	Process	>98
4. Frequency with which risk for adverse events is assessed and documented before sedation is started	3	Process	>98
5. Frequency with which prophylactic antibiotics are administered for appropriate indication	Varies	Process	>98
6. Frequency with which a sedation plan is documented	Varies	Process	>98
7. Frequency with which management of antithrombotic therapy is formulated and documented before the procedure	3	Process	N/A
8. Frequency with which a team pause is conducted and documented	3	Process	>98
9. Frequency with which endoscopy is performed by an individual who is fully trained and credentialed to perform that particular procedure	3	Process	>98
Intraprocedure			
10. Frequency with which photodocumentation is performed	3	Process	N/A
11. Frequency with which patient monitoring during sedation is performed and documented	3	Process	>98
12. Frequency with which the doses and routes of administration of all medications used during the procedure are documented	3	Process	>98
13. Frequency with which use of reversal agents is documented	3	Process	>98
14. Frequency with which procedure interruption and premature termination because of sedation-related issues is documented	3	Process	>98
Postprocedure			
15. Frequency with which discharge from the endoscopy unit according to predetermined discharge criteria is documented	3	Process	>98
16. Frequency with which patient instructions are provided	3	Process	>98
17. Frequency with which the plan for pathology follow-up is specified and documented	3	Process	>98
18. Frequency with which a complete procedure report is created	3	Process	>98

TABLE 2. Continued

Quality indicator	Grade of recommendation	Measure type	Performance target (%)
19. Frequency with which adverse events are documented	3	Process	>98
20. Frequency with which adverse events occur	3	Outcome	N/A
21. Frequency with which postprocedure and late adverse events occur and are documented	3	Outcome	N/A
22. Frequency with which patient satisfaction data are obtained	3	Process	N/A
23. Frequency with which communication with referring providers is documented	3	Process	N/A

N/A, Not available.
*This list of potential quality indicators is meant to be a comprehensive list of measurable endpoints. It is not the intention of the task force that all endpoints be measures in every practice setting. In most cases, validation may be required before a given endpoint may be adopted universally.

has identified specific clinical situations for which EUS is deemed an appropriate diagnostic or therapeutic procedure (Table 3).[6] EUS generally is not indicated for staging of tumors shown to be metastatic by other imaging methods (unless the results are the basis for therapeutic decisions or unless the procedure is performed to confirm a diagnosis by tissue sampling). It is fully expected that certain indications may change with time. In addition, the appropriate use of EUS also depends, in part, on the availability of other imaging methods, because not all patients will have reasonable access to alternatives to EUS. For this reason, 100% compliance with predetermined indications is considered restrictive.

The inclusion of an indication in the procedure documentation for all cases is a useful quality measure for two reasons. First, it provides a justification for the procedure and serves as a means of tracking compliance with accepted indications. Second, the indication places the remainder of the procedure report in a specific context wherein certain endosonographic landmarks and finding characteristics logically should follow. For example, detailed descriptions of the pancreas may not be necessary when the indication for EUS is esophageal cancer staging. However, once esophageal cancer staging is provided as the indication, certain components of the examination, such as tumor (T) and node (N) staging, including celiac axis visualization (except in cases when the tumor cannot be safely traversed), are expected and their subsequent inclusion would reflect a thorough EUS.

2. *Frequency with which consent is obtained, including specific discussions of risks associated with EUS, and fully documented*

Level of evidence: 3
Performance target: >98%
Type of measure: process
The consent should address the relevant and substantial adverse events pertaining to each specific EUS procedure in addition to the risks associated with all endoscopic procedures.
Discussion: EUS and EUS-FNA present risks of unique adverse events beyond those associated with standard endoscopy. A review of the adverse events specific to EUS have been published previously and are detailed in the following section.[8,9] In most instances, EUS requires passage of large echoendoscopes or endoscopes with relatively rigid portions. Although EUS is associated with an increased risk of perforation, this adverse event is rare. Esophageal or duodenal perforations are rare adverse events associated with EUS.[8-15] The incidence of cervical esophageal perforation during intubation ranges from 0.03% to 0.06%.[11,12] Perforation risk also may be higher when staging esophageal cancer, particularly in the setting of before-EUS dilation of an obstructing malignancy (range 0%-24%).[14,16-18] Perforation related to dilation of malignant esophageal strictures for complete EUS examination is rare when the procedure is performed cautiously by experienced operators.[16] Dilation of esophageal cancer, advanced patient age, difficult esophageal intubation, and lack of operator experience have been identified as risk factors for esophageal perforation.[8,11,14] FNA introduces an increased risk of bleeding (0.5%), infection (<1%),[8-10,13-15,19-22] and pancreatitis (≤2% and greater for cystic lesions compared with solid lesions).[8-10,19,21,23-26] Tumor seeding along the FNA tract has been reported in very rare circumstances.[27-32] Routine performance of bile duct EUS-FNA for primary tumor diagnosis (cholangiocarcinoma) is not recommended in surgical candidates because of the small risk of tumor seeding and negative impact on transplant

TABLE 3. Appropriate indications for EUS[4,7]

Staging of tumors of the GI tract, pancreas, bile ducts, and mediastinum including lung cancer
Evaluating abnormalities of the GI tract wall or adjacent structures
Tissue sampling of lesions within, or adjacent to, the wall of the GI tract
Evaluation of abnormalities of the pancreas, including masses, pseudocysts, and chronic pancreatitis
Evaluation of abnormalities of the biliary tree
Placement of radiologic (fiducial) markers into tumors within or adjacent to the wall of the GI tract
Treatment of symptomatic pseudocysts by creating an enteral-cyst communication
Providing access into the bile ducts or pancreatic duct, either independently or as an adjunct to ERCP
Evaluation for perianal and perirectal disorders (anal sphincter injuries, fistulae, abscesses)
Evaluation of patients at increased risk of pancreatic cancer
Celiac plexus block or neurolysis

candidacy or outcomes after resection for patients with resectable disease.[33] Celiac plexus neurolysis or celiac plexus block carry unique risks of transient hypotension (1%) and diarrhea (4%-15%), in addition to standard risks.[8] The consent form used by the endosonographer should be comprehensive enough to include these adverse events.

3. *Frequency with which appropriate antibiotics are administered in the setting of FNA of cystic lesions*
   Level of evidence: 2C
   Performance target: N/A
   Type of measure: process
   Discussion: There have been no randomized trials conducted to determine the need for prophylactic antibiotics in the setting of EUS-FNA. The risk of bacteremia after EUS-FNA is low (0%-6%) and comparable with that of diagnostic endoscopy.[22,34-36] This holds true for patients undergoing EUS-FNA of the rectum and perirectal space. In a prospective study of 100 patients who underwent EUS-FNA for lower GI tract lesions, the incidence of bacteremia was 2%.[22] In general, the risk of clinically significant infectious adverse events after EUS-FNA of solid lesions is very low (range 0%-0.6%).[13-15,19-22] Infectious adverse events were reported in 0.04% of patients undergoing EUS-FNA in a recent systematic review.[10] The rate of infection related to EUS-FNA of pancreatic cysts was relatively low (0.5%) as well and was attributed to the routine use of prophylactic antibiotics.[10] On the other hand, EUS-FNA of mediastinal cysts is associated with high rates of infectious adverse events including life-threatening mediastinitis.[8] The recommendation of administering antibiotics before EUS-FNA of pancreatic cysts has been challenged in a retrospective study that showed no protective effect from periprocedural prophylactic antibiotics in patients undergoing EUS-FNA of pancreatic cysts.[37] The ASGE suggests antibiotics before EUS-FNA of mediastinal cysts and advises against administration of prophylactic antibiotics before EUS-FNA of pancreatic and peripancreatic cystic lesions.[38] Prophylaxis, when deemed necessary, involves administration of an antibiotic such as a fluoroquinolone administered before the procedure and continued for 3 to 5 days postprocedure. Administration of prophylactic antibiotics for lower GI tract lesions should be made on a case-by-case basis. ASGE advises against antibiotic prophylaxis before diagnostic EUS or EUS-FNA of solid lesions in the lower GI tract.[38,39]

4. *Frequency with which EUS examinations are performed by trained endosonographers*
   Level of evidence: 3
   Performance target: >98%
   Type of measure: process
   Discussion: Although it is beyond the scope of this article to discuss training requirements and competency assessment, a trained endosonographer is defined as one who has undergone formal training and gained the necessary technical and cognitive skills. Training in EUS requires the development of technical and cognitive skills beyond that required for standard endoscopic procedures. The value of EUS in provision of patient care is directly proportional to the training, skill, and experience of the endosonographer. Recognizing the specialized nature of EUS and EUS-FNA, ASGE has published specific criteria for the training of, and the granting of clinical privileges for, individuals who want to perform these procedures.[40-42] These guidelines have not been validated and do not account for different rates at which people learn. Unfortunately, there is a dearth of data on the intensity and length of training, the requisite curriculum and extent of theoretical learning, and minimum number of procedures required to ensure competency. Given the variability in

diagnostic yield associated with relative experience and training in this procedure, it is a reasonable expectation that the likelihood of a high-quality procedure is increased by having a fully trained endosonographer perform the examination.

Preprocedure research questions

1. Does EUS impact patient management decisions for each specific indication?
2. Does EUS improve patient outcomes for each specific indication?
3. What is the absolute impact of prophylactic antibiotics on the risk of infection after FNA of cystic lesions?
4. How often is EUS performed for nonstandard indications in clinical practice?
5. Is there a difference in findings or outcomes when EUS is performed for non-standard indications?
6. How much training is required for individuals performing EUS before they can achieve staging accuracy and diagnostic FNA yields comparable to those of published literature?

Intraprocedure quality indicators

The intraprocedure period extends from the administration of sedation to the removal of the endoscope. This period includes all the technical aspects of the procedure including completion of the examination and of therapeutic maneuvers. Common to most endoscopic procedures is the provision of sedation and need for patient monitoring. Intraprocedure quality indicators specific to performance of EUS include the following:

5. *Frequency with which the appearance of relevant structures, specific to the indication for the EUS, is documented*
   Level of evidence: 3
   Performance target: >98%
   Type of measure: process
   Documentation for each of the following indications should include the following items:
   1. In the setting of esophageal cancer staging without obstruction, location of the gastroesophageal junction and visualization of the celiac axis and left lobe of the liver (to rule out metastatic disease) should be documented.
   2. In the setting of evaluating for the presence of pancreaticobiliary disease, visualization of the entire pancreas (describing features of chronic pancreatitis and pancreatic cysts when present) along with evaluation of the pancreatic duct should be documented. Description of biliary abnormalities (eg, stones, dilation) should be documented.
   3. In the setting of EUS for lower GI tract indications such as rectal cancer, location of the tumor and visualization of surrounding structures such as iliac vessels, genitourinary structures, and sphincter apparatus and evaluation for lymphadenopathy should be documented.

   Discussion: To maximize clinical efficacy, EUS should provide all pertinent information relevant to the procedure's indication. The endosonographer must visualize specific structures depending on the disease process being investigated and should subsequently document these findings in writing or with photographic documentation.

6a. *Frequency with which all GI cancers are staged with the American Joint Committee on Cancer (AJCC)/Union for International Cancer Control (UICC) TNM staging system*[43,44] *(priority indicator)*
   Level of evidence: 3
   Performance target: >98%
   Type of measure: process

6b. *Frequency with which pancreatic mass measurements are documented along with evaluation for vascular involvement, lymphadenopathy, and distant metastases*
   Level of evidence: 3
   Performance target: >98%
   Type of measure: process

6c. *Frequency with which EUS wall layers involved by subepithelial masses are documented*
   Level of evidence: 3
   Performance target: >98%
   Type of measure: process
   Discussion: A diagnosis based on EUS findings, with or without cytology from FNA, requires not only an accurate localization and description of sonographic findings but also an accurate interpretation of these findings within the individual patient's clinical context. Currently, the AJCC/UICC TNM (tumor, node, metastasis) systems are the most widely used methods for staging GI malignancies.[43,44] Therefore, to maximize the utility of EUS in the setting of cancer staging, the elements necessary to assign both T and N stages should be obtained during the procedure and documented in writing and with saved images. This includes measurements of the mass, because T staging may depend on tumor size as in pancreatic cancer. Examination should include evaluation of vascular involvement (eg, portal vein/superior mesenteric vein and celiac axis, hepatic artery and superior mesenteric artery involvement in pancreatic cancer) and distant metastasis, which also impacts the T stage and candidacy for resectability. In the setting of subepithelial lesions, the differential diagnosis is based on wall layer of origin, echo characteristics, and size of lesion. Therefore, these findings should be documented in every report.
   Several recent reports have described the accuracy of T and N staging with EUS in relation to cancers of the pancreas, esophagus, stomach, and rectum. Accurate staging of pancreatic cancer plays an integral role in the initial decision making process for patients

with pancreatic cancer. In pancreatic cancer, results from contemporary studies have reported accuracy of T staging ranging from 62% to 67%, [45-48] with earlier studies reporting higher accuracy rates (85%-94%).[49-51] In the absence of distant metastasis, the presence and degree of contact between the tumor and the peripancreatic vessels is of paramount importance in determining surgical resectability. In a meta-analysis, the sensitivity and specificity of EUS in diagnosing vascular invasion was 73% (95% CI, 68.8-76.9) and 90% (95% CI, 87.9-92.2).[52] Results from available data with regard to accuracy of EUS in predicting vascular invasion are variable, with a wide range suggesting the operator dependency and variability. The task force acknowledges this and hence does not make accuracy of vascular invasion as a quality indicator but recommends documentation of vascular invasion as a quality indicator. Similarly, variable rates of accuracy for N staging have been reported in pancreatic cancer (range 40%-85%).[45,47,48,50,51,53,54] In esophageal cancer, sensitivity and specificity of EUS for T staging has ranged from 81% to 92% and 94% to 99%, respectively.[55] Although the role of EUS has been questioned in the setting of Barrett's-esophagus–related neoplasia (high-grade dysplasia and intramucosal cancer),[56,57] EUS has moderate accuracy rates in differentiating mucosal (T1a) versus submucosal (T1b) esophageal cancer, although this is largely being supplanted by EMR and/or endoscopic submucosal dissection and direct pathology staging.[58] Sensitivity and specificity of EUS for N staging was 80% (95% CI, 75-84) and 70% (95% CI, 65-75) in a meta-analysis.[59] In gastric cancer, a recent meta-analysis reported high accuracy rates in differentiating T1-2 from T3-4 disease (sensitivity 86% [95% CI, 81-90] and specificity 91% [95% CI, 89-93]. EUS for lymph node status was less reliable sensitivity 69% [95% CI, 63-74] and specificity 84% [95% CI, 81-88]).[60] The sensitivity and specificity for T staging in rectal cancer was 88% and 98% for T1, 81% and 96% for T2, 96% and 91% for T3, and 95% and 98% for T4 cancer, respectively.[61] However, recent studies have questioned these high accuracy rates and have suggested that magnetic resonance imaging may have similar accuracy rates in the T and N staging of rectal cancer.[62,63]

7a. *Percentage of patients with distant metastasis, ascites, and lymphadenopathy undergoing EUS-guided FNA who have tissue sampling of both the primary tumor and lesions outside of the primary field when this would alter patient management*
Level of evidence: 1C
Performance target: >98%
Type of measure: process

7b. *Diagnostic rate of adequate sample in all solid lesions undergoing EUS-FNA (adequate sample is defined by the presence of cells and/or tissue from the representative lesion in question)*
Level of evidence: 3
Performance target: ≥85%
Type of measure: outcome

7c. *Diagnostic rates and sensitivity for malignancy in patients undergoing EUS-FNA of pancreatic masses (priority indicator)*
Level of evidence: 1C
Performance target: Diagnostic rate of malignancy in patients undergoing EUS-FNA of all pancreatic masses, ≥70% and sensitivity of malignancy among patients with pancreatic cancer, ≥85%
Type of measure: outcome
Discussion: The additional clinical information obtained from FNA can increase the diagnostic accuracy of EUS significantly by confirming a pathologic diagnosis, by obtaining more accurate nodal staging in malignancy, and by yielding fluid for various analyses, including chemical analyses, tumor markers, and bacterial and/or fungal stains or culture. FNA is not feasible or appropriate in all conditions. Sampling a lymph node by traversing the primary tumor with the FNA needle should be avoided, because this may result in a false-positive lymph node cytology result and can potentially seed a previously benign lymph node with malignant cells from the primary tumor. The need for pretreatment FNA of pancreas tumors is variable. The primary value of FNA is to confirm malignancy, particularly when chemoradiotherapy is considered prior to or in lieu of surgery or to exclude lesions such as metastases to the pancreas, mass-forming pancreatitis, non-adenocarcinoma histology, and lymphoma. However, when FNA is appropriate, the endosonographer should make every effort to obtain adequate cytologic material to confirm a diagnosis.
Accuracy of EUS-FNA has been evaluated in several studies in patients with cancers of the pancreas, esophagus, stomach, bile duct, and rectum. Data from these studies provide a benchmark for quality performance measurement in EUS. A multicenter, retrospective study that included 1075 patients who underwent EUS-FNA of solid pancreatic masses at 21 centers (81% academic) with 41 endosonographers reported an overall diagnostic rate of malignancy of 71% (95% CI, 69-74).[64] Sensitivity and specificity that uses the criterion standard of either surgical pathology or long-term follow-up are ideal benchmarks for pancreatic EUS-FNA performance. A recent meta-analysis that included studies that met this criterion reported a pooled sensitivity of 85% (95% CI, 84-86) and specificity of 98% (95% CI, 97-99), with higher accuracy of EUS-FNA reported in prospective, multicenter studies.[65]
In the setting of esophageal cancer in the thoracic esophagus, malignant celiac axis lymph nodes no longer confer M1a status and, per the new staging system, a regional lymph node has been redefined to include any paraesophageal node extending from

cervical nodes to celiac nodes.[66] EUS-FNA for lymph node staging in esophageal cancer is an accurate staging modality with sensitivity of 83% (95% CI, 70-93), specificity of 93% (95% CI, 77%-99%), and accuracy of 87% (95% CI, 77-94) as reported in a prospective study that included 76 consecutive patients with pathologic evaluation of resected lymph nodes.[67] Retrospective studies that focused primarily on celiac lymph nodes reported sensitivity of 88% to 100%, specificity of 100%, and accuracy rates ranging from 87% to 100% for detection of lymph node metastases.[68-71]

Several studies have reported the use of EUS-FNA for the diagnosis of cholangiocarcinoma in the setting of indeterminate extrahepatic strictures. Reported sensitivity ranges from 29% to 89%[72-77] with a higher sensitivity reported for distal compared with proximal strictures (81% vs 59%; $P = .04$) in a single study.[77] The conventional criteria for malignant lymph nodes at EUS (size >1 cm, round, hypoechoic, and homogenous) have a poor predictive value in malignant lymphadenopathy associated with cholangiocarcinoma.[78] Hence, given the potential for avoiding unnecessary neoadjuvant therapy and staging laparotomy, a low threshold for sampling lymphadenopathy in this situation should be maintained. EUS-FNA should be performed only when results are likely to alter decision making (primary surgical resection or definitive or neoadjuvant chemoradiation). EUS-FNA also should be performed in patients with suspected distant metastases, given the potential to significantly change patient management.

The involvement of an on-site cytopathologist during EUS-FNA may help limit the number of FNA passes taken and increase the overall diagnostic accuracy of the procedure, although data are inconclusive.[9,79-85] The impact of on-site cytopathology evaluation in terms of diagnostic yield, number of passes, repeat procedures, and procedure time has not been studied in a randomized, controlled trial. However, it is recognized that not all endosonographers will have access to this degree of service. Therefore, for situations in which an on-site cytopathologist or cytotechnologist is not available, 5 to 7 FNA passes for pancreas masses and 2 to 4 passes for lymph nodes or suspected liver metastases are advised.[86-88] Other methods to increase cytologic adequacy and accuracy have not been definitively shown to be superior. EUS-FNA can be performed by using 25-gauge, 22-gauge, or 19-gauge needles. Randomized, controlled trials comparing 25-gauge and 22-gauge needles demonstrated no difference in diagnostic accuracy between the two groups.[89-91] A recent meta-analysis of 8 studies involving 1292 patients undergoing EUS-FNA (25-gauge, 565 patients and 22-gauge, 799 patients) showed that a 25-gauge needle was more sensitive than a 22-gauge needle for diagnosing pancreatic malignancy (pooled sensitivity, 25-gauge: 0.93 [95% CI, 0.91-0.96] vs 22-gauge: 0.85 [95% CI, 0.82-0.88]).[92] A randomized, controlled trial comparing 19-gauge and 22-gauge needle systems in patients undergoing EUS-FNA of pancreatic masses demonstrated a higher diagnostic accuracy rate and the presence of superior cellular material by using the 19-gauge needle. However, a significantly lower technical success rate was reported by using the 19-gauge needle system.[93] Large needle gauges (19-gauge) provide a larger specimen but are limited to transgastric biopsy in most cases and for EUS-guided interventions such as pseudocyst drainage. Few randomized, controlled trials have demonstrated no advantage in the routine use of a stylet during EUS-FNA.[94-96] In recent years, the technique of performing EUS-FNA passes without the use of a stylet has gained popularity but has not been adopted by all endosonographers. Use of traditional true-cut biopsy has not been shown to be superior to FNA and is associated with a high failure rate in transduodenal puncture.[9] Recent availability of small-gauge core biopsy needles (25-gauge and 22-gauge) and flexible 19-gauge needles offers an opportunity for research.

Intraprocedure research questions

1. What are the thresholds for accurate T and N staging of GI malignancies?
2. How do community practices compare with academic centers with regard to EUS staging and EUS-FNA accuracy?
3. Under what circumstances does FNA change patient management?
4. What is the optimal technique for performing EUS-FNA, and what are the variables that impact obtaining adequate specimens?
5. How does on-site cytopathology evaluation during EUS-FNA impact diagnostic yield, number of passes, repeat procedures, and procedure time?
6. What are the optimal methods for tissue processing of FNA specimens?

Postprocedure quality indicators

The postprocedure period extends from the time the endoscope is removed to subsequent follow-up. Postprocedure activities include providing instructions to the patient, documentation of the procedure, recognition and documentation of adverse events, pathology follow-up, communication with referring physicians, and assessing patient satisfaction.[5] Postprocedure quality indicators specific to performance of EUS include the following:

8. *Frequency with which the incidence of adverse events after EUS-FNA (acute pancreatitis, bleeding, perforation, and infection) is documented*
   Level of evidence: 3
   Performance target: >98%
   Type of measure: process

9. *Incidence of adverse events after EUS-FNA (acute pancreatitis, bleeding, perforation, and infection) (priority indicator)*
   Level of evidence: 1C
   Performance target: acute pancreatitis <2%, perforation <0.5%, clinically significant bleeding <1%
   Type of measure: outcome
   Discussion

A. Overall and specific adverse event rates. The overall safety of EUS-FNA is well-established, with a low overall adverse event rate. The main adverse events include acute pancreatitis, bleeding, and infection. Two other adverse events that merit mention include tumor seeding and false-positive EUS-FNA cytology results.

Variable rates of morbidity related to EUS-FNA have been reported, ranging from 0% to 2.5%.[13-15,19-21] A recent systematic review that included 10,941 patients reported an overall EUS-FNA specific morbidity rate of 0.98% (107/10,941) and mortality rate of 0.02% (2/10,941).[10] Patients undergoing EUS-FNA of the pancreas for evaluation of pancreatic masses, cystic lesions, or lesions of the pancreatic duct are at risk of developing pancreatitis, likely as a result of direct tissue injury as the needle traverses pancreatic tissue. The incidence of pancreatitis in this setting, including data from prospective series, has ranged between 0% and 2%.[19,21,23-26] The rate of pancreatitis was 0.44% (36/8246) in a systematic review, mild-moderate severity in most patients.[10] Acute clinically significant bleeding related to EUS-FNA is a rare adverse event, and incidence has ranged from 0 to 0.5%.[10,13-15,19-21] Mild intraluminal bleeding has been reported in up to 4% of cases,[97] extraluminal bleeding in 1.3% to 2.6% of cases,[26,98] and intracystic bleeding in up to 6% of cases during EUS-FNA of pancreatic cysts.[99] The risk of clinically significant infectious adverse events after EUS-FNA of solid lesions is very low (range 0%-0.6%).[13-15,19-22] Infectious adverse events were reported in 5 of 10,941 (0.04%) patients in a recent systematic review.[10] The rate of infection related to EUS-FNA of pancreatic cysts is relatively low (0.5%) and is attributed to the routine use of prophylactic antibiotics.[10] On the other hand, EUS-FNA of mediastinal cysts is associated with high rates of infectious adverse events including life-threatening mediastinitis.[8]

B. Tumor seeding after EUS-FNA. Needle track seeding or implantation metastasis has been reported after EUS-FNA and deserves special mention. This adverse event has been described as case reports.[27-31] However, the true incidence of this adverse event is difficult to assess because of the high mortality of patients ineligible for potentially curable therapy. In addition, tumor seeding may occur at sites that are outside the field of primary resection. In a prospective study of 140 patients undergoing EUS, which included patients with cancer and benign lesions, the luminal fluid aspirated through the accessory channel before and after FNA was submitted for cytologic analysis. Cytology examination of the luminal fluid showed positive results for malignancy in 48% of patients and 10% in patients with extraluminal cancer. Post-FNA luminal fluid cytology was unexpectedly positive in 3 of 26 pancreatic cancer patients. This suggests that EUS-FNA may withdraw malignant cells from the tumor into the GI lumen and potentially cause seeding from the target organ.[32] Another retrospective study demonstrated a higher rate of peritoneal carcinomatosis related to pancreatic cancer in patients undergoing percutaneously guided FNA compared with EUS-FNA (16.3% vs 2.2%; $P < .025$).[100] The concern for tumor seeding is of greatest relevance in patients with suspected cholangiocarcinoma and EUS-FNA of the primary tumor and is considered as a contraindication to liver transplantation for cholangiocarcinoma. A recent study evaluated the incidence of tumor seeding in 191 patients with locally unresectable hilar cholangiocarcinoma undergoing liver transplant evaluation. There were 16 patients who underwent transperitoneal FNA (16 percutaneous, 3 EUS)—6 were positive for malignancy, 9 negative, and 1 had equivocal results. During operative staging, peritoneal metastasis was seen in 5 of 6 (83%) patients with positive FNA versus 0 of 9 (0%) with negative FNA. Peritoneal metastasis was significantly higher in patients with positive preoperative FNA compared with those not undergoing transperitoneal sampling (5/6 [83%] vs 14/175 [8%]; $P = .009$).[33]

C. False-positive EUS-FNA cytology results. The incidence of false-positive EUS-FNA cytology results ranges from 1.1% to 5.3%.[101-103] In a study that matched 377 EUS-FNA cytology results of positive or suspicious with surgical specimens in patients who had not received any neoadjuvant chemoradiation, a false-positive rate of 5.3% (increased to 7.2% if false-suspicious included) was reported. The false positive rate was higher in non-pancreatic FNA compared with pancreatic FNA (15% vs 2.2%; $P = .0001$). Discordant results were then blindly assessed by 3 cytopathologists, and reasons for false-positive results included epithelial cell contamination and pathology misinterpretation.[101] Another retrospective study that involved 367 patients with solid pancreatic lesions in whom EUS-FNA cytology results were positive or suspicious for malignancy resulting in surgical resection, the false positive rate was 1.1% (3.8% if false-suspicious included). These false-positive results were attributed to pathology misinterpretation in the setting of chronic pancreatitis.[102]

D. Risk factors for adverse events related to EUS-FNA. Given the rarity of EUS-FNA–related adverse events, studies assessing predictors for adverse events are hampered by the lack of power to evaluate risk factors. Prospective studies report a higher cumulative FNA-related morbidity rate compared with retrospective studies (59/3426 [1.72%] vs 48/7515 [0.64%]). These findings hold true for FNA-related adverse events of pancreatic lesions (mass and cystic lesion).[10] EUS-FNA of cystic lesions in the pancreas is associated with a higher rate of adverse events compared with EUS-FNA of solid lesions, although it is still quite low.[10,13] The number of passes is not associated with the risk of adverse events.[9] Similarly, needle

TABLE 4. Summary of proposed quality indicators for EUS*

Quality indicator	Grade of recommendation	Type of measure	Performance target (%)
Preprocedure			
1. Frequency with which EUS is performed for an indication that is included in a published standard list of appropriate indications and the indication is documented	1C	Process	>80
2. Frequency with which consent is obtained, including specific discussions of risks associated with EUS, and fully documented	3	Process	>98
3. Frequency with which appropriate antibiotics are administered in the setting of FNA of cystic lesions	2C	Process	N/A
4. Frequency with which EUS exams are performed by trained endosonographers	3	Process	>98
Intraprocedure			
5. Frequency with which the appearance of relevant structures, specific to the indication for the EUS, is documented	3	Process	>98
6a. Frequency with which all gastrointestinal cancers are staged with the American Joint Committee on Cancer (AJCC)/Union for International Cancer Control (UICC) TNM staging system (priority indicator)	3	Process	>98
6b. Frequency with which pancreatic mass measurements are documented along with evaluation for vascular involvement, lymphadenopathy and distant metastases	3	Process	>98
6c. Frequency with which EUS wall layers involved by subepithelial masses are documented	3	Process	>98
7a. Percentage of patients with distant metastasis, ascites, and lymphadenopathy undergoing EUS-guided FNA who have tissue sampling of both the primary tumor diagnosis and lesions outside of the primary field when this would alter patient management	1C	Process	>98
7b. Diagnostic rate of adequate sample in all solid lesions undergoing EUS-FNA (adequate sample is defined by the presence of cells/tissue from the representative lesion in question)	3	Outcome	≥85
7c. Diagnostic rates and sensitivity for malignancy in patients undergoing EUS-FNA of pancreatic masses (priority indicator)	1C	Outcome	Diagnostic rate: ≥70 Sensitivity: ≥85
Postprocedure			
8. Frequency with which the incidence of adverse events after EUS-FNA (acute pancreatitis, bleeding, perforation and infection) is documented	3	Process	>98
9. Incidence of adverse events after EUS-FNA (acute pancreatitis, bleeding, perforation and infection) (priority indicator)	1C	Outcome	Acute pancreatitis: <2% Perforation: <0.5% Clinically significant bleeding: <1%

N/A, Not available.

*This list of potential quality indicators was meant to be a comprehensive listing of measurable endpoints. It is not the intention of the task force that all endpoints be measured in every practice setting. In most cases, validation may be required before a given endpoint may be universally adopted.

TABLE 5. Priority quality indicators for endoscopic ultrasound*

Frequency with which all GI cancers are staged with the AJCC/UICC TNM staging system
Diagnostic rates and sensitivity for malignancy in patients undergoing EUS-guided FNA of pancreatic masses
The incidence of adverse events after EUS-guided FNA (acute pancreatitis, bleeding, perforation, and infection)

AJCC, American Joint Committee on Cancer; *UICC,* Union for International Cancer Control; *TNM,* tumor, node, metastasis.
*See text for specific targets and discussion.

gauge does not appear to increase the risk of adverse events, although these studies were not powered to detect a difference in this endpoint.[91,93] EUS-guided true-cut biopsies appear to have a similar safety profile compared with standard EUS-FNA.[104-106] However, EUS-guided true-cut biopsies are not routinely performed transduodenally and for lesions <2 cm. The safety of a core biopsy needle was described in a recent randomized, controlled trial comparing a 22-gauge EUS-FNA needle to a 22-gauge EUS-fine needle biopsy needle.[107]

Postprocedure research questions

1. What are the estimates of adverse events related to EUS-FNA in community practices?
2. What are the true estimate and clinical significance of tumor seeding and false positive rates after EUS-FNA?
3. What is the incidence of the adverse events of EUS-guided core biopsies, and do such biopsies improve outcomes over standard FNA sampling?
4. Is it feasible to incorporate data regarding surgical pathology and long-term follow-up in patients undergoing EUS?
5. How can the diagnostic yield of EUS-FNA be improved?
6. What is the frequency with which EUS alters patient management and long-term outcomes?[108-111]

Priority indicators for EUS

For EUS, the recommended priority indicators among all the proposed indicators (Table 4) are:

1. Frequency with which all GI cancers are staged with the AJCC/UICC TNM staging system
2. Diagnostic rates of malignancy and sensitivity in patients undergoing EUS-FNA of pancreatic masses
3. The incidence of adverse events after EUS-FNA (bleeding, perforation, and acute pancreatitis) (Table 5)

For each of these indicators, reaching the recommended performance target is considered strongly associated with important clinical outcomes. These indicators can be measured readily in a manageable number of examinations, and for each there is evidence of substantial variation in performance.[112,113]

There is evidence that simple educational and corrective measures can improve endoscopist performance. The primary purpose of measuring quality indicators is to improve patient care by identifying poor performers and retraining them so that they might be able to meet the performance targets for these important aspects of the procedure.

Conclusion

The quality indicators proposed in this document were selected, in part, because of their ease of implementation, monitoring, and reporting (Table 4). The task force has attempted to create a comprehensive list of potential quality indicators. We recognize that not every indicator will be applicable to every practice setting. Facilities should select the subset most appropriate to their individual needs. We recognize that the field of EUS continues to expand, with the possible appearance of new indications and adverse events. Therefore, these quality indicators should be updated as the need arises. With the increasing demand for EUS, the number of physicians performing this complex procedure will continue to grow. It is the hope of the ACG, ASGE, and AGA that these measures and targets not only guide practicing endoscopists who perform EUS but also that they be incorporated into the training of new endosonographers to ensure that all patients receive the highest quality care possible.

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Abbreviations: ACG, American College of Gastroenterology; AJCC, American Joint Committee on Cancer; ASGE, American Society for Gastrointestinal Endoscopy; EUS-FNA, EUS-guided FNA; TNM, tumor, node, metastasis; UICC, Union for International Cancer Control.

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REFERENCES

1. Chassin MR, Galvin RW. The urgent need to improve health care quality. Institute of Medicine National Roundtable on Health Care Quality. JAMA 1998;280:1000-5.
2. Petersen BT. Quality assurance for endoscopists. Best Pract Res Clin Gastroenterol 2011;25:349-60.
3. Jacobson BC, Chak A, Hoffman B, et al. Quality indicators for endoscopic ultrasonography. Gastrointest Endosc 2006;63:S35-8.
4. Faigel DO, Pike IM, Baron TH, et al. Quality indicators for gastrointestinal endoscopic procedures: an introduction. Gastrointest Endosc 2006;63:S3-9.
5. Rizk MK, Sawhney MS, Cohen J, et al. Quality indicators common to all GI endoscopic procedures. Gastrointest Endosc 2015;81:3-16.
6. Early DS, Ben-Menachem T, Decker GA, et al. Appropriate use of GI endoscopy. Gastrointest Endosc 2012;75:1127-31.
7. Dumonceau JM, Polkowski M, Larghi A, et al. Indications, results, and clinical impact of endoscopic ultrasound (EUS)-guided sampling in gastroenterology: European Society of Gastrointestinal Endoscopy (ESGE) Clinical Guideline. Endoscopy 2011;43:897-912.
8. Adler DG, Jacobson BC, Davila RE, et al. ASGE guideline: complications of EUS. Gastrointest Endosc 2005;61:8-12.
9. Polkowski M, Larghi A, Weynand B, et al. Learning, techniques, and complications of endoscopic ultrasound (EUS)-guided sampling in gastroenterology: European Society of Gastrointestinal Endoscopy (ESGE) Technical Guideline. Endoscopy 2012;44:190-206.
10. Wang KX, Ben QW, Jin ZD, et al. Assessment of morbidity and mortality associated with EUS-guided FNA: a systematic review. Gastrointest Endosc 2011;73:283-90.
11. Das A, Sivak MV Jr, Chak A. Cervical esophageal perforation during EUS: a national survey. Gastrointest Endosc 2001;53:599-602.
12. Eloubeidi MA, Tamhane A, Lopes TL, et al. Cervical esophageal perforations at the time of endoscopic ultrasound: a prospective evaluation of frequency, outcomes, and patient management. Am J Gastroenterol 2009;104:53-6.
13. Wiersema MJ, Vilmann P, Giovannini M, et al. Endosonography-guided fine-needle aspiration biopsy: diagnostic accuracy and complication assessment. Gastroenterology 1997;112:1087-95.
14. Mortensen MB, Fristrup C, Holm FS, et al. Prospective evaluation of patient tolerability, satisfaction with patient information, and complications in endoscopic ultrasonography. Endoscopy 2005;37:146-53.
15. Bournet B, Migueres I, Delacroix M, et al. Early morbidity of endoscopic ultrasound: 13 years' experience at a referral center. Endoscopy 2006;38:349-54.
16. Pfau PR, Ginsberg GG, Lew RJ, et al. Esophageal dilation for endosonographic evaluation of malignant esophageal strictures is safe and effective. Am J Gastroenterol 2000;95:2813-5.
17. Wallace MB, Hawes RH, Sahai AV, et al. Dilation of malignant esophageal stenosis to allow EUS guided fine-needle aspiration: safety and effect on patient management. Gastrointest Endosc 2000;51:309-13.
18. Van Dam J, Rice TW, Catalano MF, et al. High-grade malignant stricture is predictive of esophageal tumor stage. Risks of endosonographic evaluation. Cancer 1993;71:2910-7.
19. Williams DB, Sahai AV, Aabakken L, et al. Endoscopic ultrasound guided fine needle aspiration biopsy: a large single centre experience. Gut 1999;44:720-6.
20. Al-Haddad M, Wallace MB, Woodward TA, et al. The safety of fine-needle aspiration guided by endoscopic ultrasound: a prospective study. Endoscopy 2008;40:204-8.
21. Eloubeidi MA, Tamhane A, Varadarajulu S, et al. Frequency of major complications after EUS-guided FNA of solid pancreatic masses: a prospective evaluation. Gastrointest Endosc 2006;63:622-9.
22. Levy MJ, Norton ID, Clain JE, et al. Prospective study of bacteremia and complications With EUS FNA of rectal and perirectal lesions. Clin Gastroenterol Hepatol 2007;5:684-9.
23. Eloubeidi MA, Gress FG, Savides TJ, 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.
24. Eloubeidi MA, Chen VK, Eltoum IA, 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.
25. Gress F, Michael H, Gelrud D, et al. EUS-guided fine-needle aspiration of the pancreas: evaluation of pancreatitis as a complication. Gastrointest Endosc 2002;56:864-7.
26. Kien-Fong Vu C, Chang F, Doig L, et al. A prospective control study of the safety and cellular yield of EUS-guided FNA or Trucut biopsy in patients taking aspirin, nonsteroidal anti-inflammatory drugs, or prophylactic low molecular weight heparin. Gastrointest Endosc 2006;63:808-13.
27. Chong A, Venugopal K, Segarajasingam D, et al. Tumor seeding after EUS-guided FNA of pancreatic tail neoplasia. Gastrointest Endosc 2011;74:933-5.
28. Ahmed K, Sussman JJ, Wang J, et al. A case of EUS-guided FNA-related pancreatic cancer metastasis to the stomach. Gastrointest Endosc 2011;74:231-3.
29. Doi S, Yasuda I, Iwashita T, et al. Needle tract implantation on the esophageal wall after EUS-guided FNA of metastatic mediastinal lymphadenopathy. Gastrointest Endosc 2008;67:988-90.
30. Paquin SC, Gariepy G, Lepanto L, et al. A first report of tumor seeding because of EUS-guided FNA of a pancreatic adenocarcinoma. Gastrointest Endosc 2005;61:610-1.
31. Shah JN, Fraker D, Guerry D, et al. Melanoma seeding of an EUS-guided fine needle track. Gastrointest Endosc 2004;59:923-4.
32. Levy MJ, Gleeson FC, Campion MB, et al. Prospective cytological assessment of gastrointestinal luminal fluid acquired during EUS: a potential source of false-positive FNA and needle tract seeding. Am J Gastroenterol 2010;105:1311-8.
33. Heimbach JK, Sanchez W, Rosen CB, et al. Trans-peritoneal fine needle aspiration biopsy of hilar cholangiocarcinoma is associated with disease dissemination. HPB (Oxford) 2011;13:356-60.
34. Janssen J, Konig K, Knop-Hammad V, et al. Frequency of bacteremia after linear EUS of the upper GI tract with and without FNA. Gastrointest Endosc 2004;59:339-44.
35. Barawi M, Gottlieb K, Cunha B, et al. A prospective evaluation of the incidence of bacteremia associated with EUS-guided fine-needle aspiration. Gastrointest Endosc 2001;53:189-92.

36. Levy MJ, Norton ID, Wiersema MJ, et al. Prospective risk assessment of bacteremia and other infectious complications in patients undergoing EUS-guided FNA. Gastrointest Endosc 2003;57:672-8.
37. Guarner-Argente C, Shah P, Buchner A, et al. Use of antimicrobials for EUS-guided FNA of pancreatic cysts: a retrospective, comparative analysis. Gastrointest Endosc 2011;74:81-6.
38. Kashab MA, Acosta RD, Bruining DH, et al. Antibiotic prophylaxis for GI endoscopy. Gastrointest Endosc 2015, In Press.
39. Banerjee S, Shen B, Baron TH, et al. Antibiotic prophylaxis for GI endoscopy. Gastrointest Endosc 2008;67:791-8.
40. Van Dam J, Brady PG, Freeman M, et al. Guidelines for training in electronic ultrasound: guidelines for clinical application. From the ASGE. American Society for Gastrointestinal Endoscopy. Gastrointest Endosc 1999;49:829-33.
41. Eisen GM, Dominitz JA, Faigel DO, et al. Guidelines for credentialing and granting privileges for endoscopic ultrasound. Gastrointest Endosc 2001;54:811-4.
42. Dimaio CJ, Mishra G, McHenry L, et al. EUS core curriculum. Gastrointest Endosc 2012;76:476-81.
43. Edge S, Byrd DR, Compton CC, et al. AJCC Cancer Staging Manual. New York: Springer; 2010.
44. Sobin L, Gospodarowicz M, Wittekind C; Union for International Cancer Control. TNM classification of malignant tumours. Wiley-Blackwell; 2010.
45. Ramsay D, Marshall M, Song S, et al. Identification and staging of pancreatic tumours using computed tomography, endoscopic ultrasound and mangafodipir trisodium-enhanced magnetic resonance imaging. Australas Radiol 2004;48:154-61.
46. Ahmad NA, Lewis JD, Siegelman ES, et al. Role of endoscopic ultrasound and magnetic resonance imaging in the preoperative staging of pancreatic adenocarcinoma. Am J Gastroenterol 2000;95:1926-31.
47. DeWitt J, Devereaux B, Chriswell M, et al. Comparison of endoscopic ultrasonography and multidetector computed tomography for detecting and staging pancreatic cancer. Ann Intern Med 2004;141:753-63.
48. Soriano A, Castells A, Ayuso C, et al. Preoperative staging and tumor resectability assessment of pancreatic cancer: prospective study comparing endoscopic ultrasonography, helical computed tomography, magnetic resonance imaging, and angiography. Am J Gastroenterol 2004;99:492-501.
49. Tio TL, Tytgat GN, Cikot RJ, et al. Ampullopancreatic carcinoma: preoperative TNM classification with endosonography. Radiology 1990;175:455-61.
50. Legmann P, Vignaux O, Dousset B, et al. Pancreatic tumors: comparison of dual-phase helical CT and endoscopic sonography. AJR Am J Roentgenol 1998;170:1315-22.
51. Gress FG, Hawes RH, Savides TJ, et al. Role of EUS in the preoperative staging of pancreatic cancer: a large single-center experience. Gastrointest Endosc 1999;50:786-91.
52. Puli SR, Singh S, Hagedorn CH, et al. Diagnostic accuracy of EUS for vascular invasion in pancreatic and periampullary cancers: a meta-analysis and systematic review. Gastrointest Endosc 2007;65:788-97.
53. Rosch T, Braig C, Gain T, et al. Staging of pancreatic and ampullary carcinoma by endoscopic ultrasonography. Comparison with conventional sonography, computed tomography, and angiography. Gastroenterology 1992;102:188-99.
54. Ahmad NA, Lewis JD, Ginsberg GG, et al. EUS in preoperative staging of pancreatic cancer. Gastrointest Endosc 2000;52:463-8.
55. Puli SR, Reddy JB, Bechtold ML, et al. Staging accuracy of esophageal cancer by endoscopic ultrasound: a meta-analysis and systematic review. World J Gastroenterol 2008;14:1479-90.
56. Young PE, Gentry AB, Acosta RD, et al. Endoscopic ultrasound does not accurately stage early adenocarcinoma or high-grade dysplasia of the esophagus. Clin Gastroenterol Hepatol;8:1037-41.
57. Pouw RE, Heldoorn N, Herrero LA, et al. Do we still need EUS in the workup of patients with early esophageal neoplasia? A retrospective analysis of 131 cases. Gastrointest Endosc 2011;73:662-8.
58. Thosani N, Singh H, Kapadia A, et al. Diagnostic accuracy of EUS in differentiating mucosal versus submucosal invasion of superficial esophageal cancers: a systematic review and meta-analysis. Gastrointest Endosc 2012;75:242-53.
59. van Vliet EP, Heijenbrok-Kal MH, Hunink MG, et al. Staging investigations for oesophageal cancer: a meta-analysis. Br J Cancer 2008;98:547-57.
60. Mocellin S, Marchet A, Nitti D. EUS for the staging of gastric cancer: a meta-analysis. Gastrointest Endosc 2011;73:1122-34.
61. Puli SR, Bechtold ML, Reddy JB, et al. How good is endoscopic ultrasound in differentiating various T stages of rectal cancer? Meta-analysis and systematic review. Ann Surg Oncol 2009;16:254-65.
62. Marusch F, Ptok H, Sahm M, et al. Endorectal ultrasound in rectal carcinoma—Do the literature results really correspond to the realities of routine clinical care? Endoscopy 2011;43:425-31.
63. Fernandez-Esparrach G, Ayuso-Colella JR, Sendino O, et al. EUS and magnetic resonance imaging in the staging of rectal cancer: a prospective and comparative study. Gastrointest Endosc 2011;74:347-54.
64. Savides TJ, Donohue M, Hunt G, et al. EUS-guided FNA diagnostic yield of malignancy in solid pancreatic masses: a benchmark for quality performance measurement. Gastrointest Endosc 2007;66:277-82.
65. Hewitt MJ, McPhail MJ, Possamai L, et al. EUS-guided FNA for diagnosis of solid pancreatic neoplasms: a meta-analysis. Gastrointest Endosc 2012;75:319-31.
66. Rice TW, Blackstone EH, Rusch VW. AJCC Cancer Staging Manual: esophagus and esophagogastric junction, 7th ed. Ann Surg Oncol 2010;17:1721-4.
67. Vazquez-Sequeiros E, Wiersema MJ, Clain JE, et al. Impact of lymph node staging on therapy of esophageal carcinoma. Gastroenterology 2003;125:1626-35.
68. Vazquez-Sequeiros E, Norton ID, Clain JE, et al. Impact of EUS-guided fine-needle aspiration on lymph node staging in patients with esophageal carcinoma. Gastrointest Endosc 2001;53:751-7.
69. Eloubeidi MA, Wallace MB, Reed CE, et al. The utility of EUS and EUS-guided fine needle aspiration in detecting celiac lymph node metastasis in patients with esophageal cancer: a single-center experience. Gastrointest Endosc 2001;54:714-9.
70. Giovannini M, Monges G, Seitz JF, et al. Distant lymph node metastases in esophageal cancer: impact of endoscopic ultrasound-guided biopsy. Endoscopy 1999;31:536-40.
71. Parmar KS, Zwischenberger JB, Reeves AL, et al. Clinical impact of endoscopic ultrasound-guided fine needle aspiration of celiac axis lymph nodes (M1a disease) in esophageal cancer. Ann Thorac Surg 2002;73:916-20, discussion 920-1.
72. Fritscher-Ravens A, Mylonaki M, Pantes A, et al. Endoscopic ultrasound-guided biopsy for the diagnosis of focal lesions of the spleen. Am J Gastroenterol 2003;98:1022-7.
73. Byrne MF, Gerke H, Mitchell RM, et al. Yield of endoscopic ultrasound-guided fine-needle aspiration of bile duct lesions. Endoscopy 2004;36:715-9.
74. Lee JH, Salem R, Aslanian H, et al. Endoscopic ultrasound and fine-needle aspiration of unexplained bile duct strictures. Am J Gastroenterol 2004;99:1069-73.
75. Eloubeidi MA, Chen VK, Jhala NC, et al. Endoscopic ultrasound-guided fine needle aspiration biopsy of suspected cholangiocarcinoma. Clin Gastroenterol Hepatol 2004;2:209-13.
76. Rosch T, Hofrichter K, Frimberger E, et al. ERCP or EUS for tissue diagnosis of biliary strictures? A prospective comparative study. Gastrointest Endosc 2004;60:390-6.
77. Mohamadnejad M, DeWitt JM, Sherman S, et al. Role of EUS for preoperative evaluation of cholangiocarcinoma: a large single-center experience. Gastrointest Endosc 2011;73:71-8.
78. Gleeson FC, Rajan E, Levy MJ, et al. EUS-guided FNA of regional lymph nodes in patients with unresectable hilar cholangiocarcinoma. Gastrointest Endosc 2008;67:438-43.

79. Klapman JB, Logrono R, Dye CE, et al. Clinical impact of on-site cytopathology interpretation on endoscopic ultrasound-guided fine needle aspiration. Am J Gastroenterol 2003;98:1289-94.
80. Iglesias-Garcia J, Dominguez-Munoz JE, Abdulkader I, et al. Influence of on-site cytopathology evaluation on the diagnostic accuracy of endoscopic ultrasound-guided fine needle aspiration (EUS-FNA) of solid pancreatic masses. Am J Gastroenterol 2011;106:1705-10.
81. Cleveland P, Gill KR, Coe SG, et al. An evaluation of risk factors for inadequate cytology in EUS-guided FNA of pancreatic tumors and lymph nodes. Gastrointest Endosc 2010;71:1194-9.
82. Cherian PT, Mohan P, Douiri A, et al. Role of endoscopic ultrasound-guided fine-needle aspiration in the diagnosis of solid pancreatic and peripancreatic lesions: Is onsite cytopathology necessary? HPB (Oxford) 2010;12:389-95.
83. Moller K, Papanikolaou IS, Toermer T, et al. EUS-guided FNA of solid pancreatic masses: high yield of 2 passes with combined histologic-cytologic analysis. Gastrointest Endosc 2009;70:60-9.
84. Turner BG, Cizginer S, Agarwal D, et al. Diagnosis of pancreatic neoplasia with EUS and FNA: a report of accuracy. Gastrointest Endosc 2010;71:91-8.
85. Schmidt RL, Witt BL, Matynia AP, et al. Rapid on-site evaluation increases endoscopic ultrasound-guided fine-needle aspiration adequacy for pancreatic lesions. Dig Dis Sci 2012;58:872-82.
86. 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.
87. LeBlanc JK, Ciaccia D, Al-Assi MT, et al. Optimal number of EUS-guided fine needle passes needed to obtain a correct diagnosis. Gastrointest Endosc 2004;59:475-81.
88. Wallace MB, Kennedy T, Durkalski V, et al. Randomized controlled trial of EUS-guided fine needle aspiration techniques for the detection of malignant lymphadenopathy. Gastrointest Endosc 2001;54:441-7.
89. Camellini L, Carlinfante G, Azzolini F, et al. A randomized clinical trial comparing 22G and 25G needles in endoscopic ultrasound-guided fine-needle aspiration of solid lesions. Endoscopy 2011;43:709-15.
90. Fabbri C, Polifemo AM, Luigiano C, et al. Endoscopic ultrasound-guided fine needle aspiration with 22- and 25-gauge needles in solid pancreatic masses: a prospective comparative study with randomisation of needle sequence. Dig Liver Dis 2011;43:647-52.
91. Siddiqui UD, Rossi F, Rosenthal LS, et al. EUS-guided FNA of solid pancreatic masses: a prospective, randomized trial comparing 22-gauge and 25-gauge needles. Gastrointest Endosc 2009;70:1093-7.
92. Madhoun MF, Wani SB, Rastogi A, 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.
93. Song TJ, Kim JH, Lee SS, et al. The prospective randomized, controlled trial of endoscopic ultrasound-guided fine-needle aspiration using 22G and 19G aspiration needles for solid pancreatic or peripancreatic masses. Am J Gastroenterol 2010;105:1739-45.
94. Wani S, Early D, Kunkel J, et al. Diagnostic yield of malignancy during EUS-guided FNA of solid lesions with and without a stylet: a prospective, single blind, randomized, controlled trial. Gastrointest Endosc 2012;76:328-35.
95. Rastogi A, Wani S, Gupta N, et al. A prospective, single-blind, randomized, controlled trial of EUS-guided FNA with and without a stylet. Gastrointest Endosc 2011;74:58-64.
96. Sahai AV, Paquin SC, Gariepy G. A prospective comparison of endoscopic ultrasound-guided fine needle aspiration results obtained in the same lesion, with and without the needle stylet. Endoscopy 2010;42:900-3.
97. Voss M, Hammel P, Molas G, et al. Value of endoscopic ultrasound guided fine needle aspiration biopsy in the diagnosis of solid pancreatic masses. Gut 2000;46:244-9.
98. Affi A, Vazquez-Sequeiros E, Norton ID, et al. Acute extraluminal hemorrhage associated with EUS-guided fine needle aspiration: frequency and clinical significance. Gastrointest Endosc 2001;53:221-5.
99. Varadarajulu S, Eloubeidi MA. Frequency and significance of acute intracystic hemorrhage during EUS-FNA of cystic lesions of the pancreas. Gastrointest Endosc 2004;60:631-5.
100. Micames C, Jowell PS, White R, et al. Lower frequency of peritoneal carcinomatosis in patients with pancreatic cancer diagnosed by EUS-guided FNA vs. percutaneous FNA. Gastrointest Endosc 2003;58:690-5.
101. Gleeson FC, Kipp BR, Caudill JL, et al. False positive endoscopic ultrasound fine needle aspiration cytology: incidence and risk factors. Gut 2010;59:586-93.
102. Siddiqui AA, Kowalski TE, Shahid H, et al. False-positive EUS-guided FNA cytology for solid pancreatic lesions. Gastrointest Endosc 2011;74:535-40.
103. Schwartz DA, Unni KK, Levy MJ, et al. The rate of false-positive results with EUS-guided fine-needle aspiration. Gastrointest Endosc 2002;56:868-72.
104. Gerke H, Rizk MK, Vanderheyden AD, et al. Randomized study comparing endoscopic ultrasound-guided Trucut biopsy and fine needle aspiration with high suction. Cytopathology 2010;21:44-51.
105. Kipp BR, Pereira TC, Souza PC, et al. Comparison of EUS-guided FNA and Trucut biopsy for diagnosing and staging abdominal and mediastinal neoplasms. Diagn Cytopathol 2009;37:549-56.
106. Wittmann J, Kocjan G, Sgouros SN, et al. Endoscopic ultrasound-guided tissue sampling by combined fine needle aspiration and trucut needle biopsy: a prospective study. Cytopathology 2006;17:27-33.
107. Bang JY, Hebert-Magee S, Trevino J, et al. Randomized trial comparing the 22-gauge aspiration and 22-gauge biopsy needles for EUS-guided sampling of solid pancreatic mass lesions. Gastrointest Endosc 2012;76:321-7.
108. Ngamruengphong S, Li F, Zhou Y, et al. EUS and survival in patients with pancreatic cancer: a population-based study. Gastrointest Endosc 2010;72:78-83, 83 e1-2.
109. Das A, Chak A, Sivak MV Jr, et al. Endoscopic ultrasonography and prognosis of esophageal cancer. Clin Gastroenterol Hepatol 2006;4:695-700.
110. Annema JT, Versteegh MI, Veselic M, et al. Endoscopic ultrasound-guided fine-needle aspiration in the diagnosis and staging of lung cancer and its impact on surgical staging. J Clin Oncol 2005;23:8357-61.
111. Wani S, Das A, Rastogi A, et al. Endoscopic ultrasonography in esophageal cancer leads to improved survival rates: results from a population-based study. Cancer 2014 Sep 18. doi: 10.1002/cncr.29043. [Epub ahead of print] PMID:25236485.
112. Faigel DO, Pike IM, Baron TH, et al. Quality indicators for gastrointestinal endoscopic procedures: an introduction. Am J Gastroenterol 2006;101:866-72.
113. Hewett DG, Rex DK. Improving colonoscopy quality through healthcare payment reform. Am J Gastroenterol 2010;105:1925-33.