Utility of quantitative elastography by Endoscopic Ultrasound (EUS) to diagnose solid pancreatic lesions (SPL)

Martin Alonso Gómez-Zuleta,1* Óscar Fernando Ruiz-Morales,2 Diego Fernando Cano-Rosales.3

Abstract
Introduction: Endoscopic ultrasonography with fine-needle aspiration allows performing a diagnosis of solid pancreatic lesions with an approximate 85% sensitivity, as referenced in specialized literature, and even lower sensitivity as per local research. To yield better sensitivity and to improve the results, it is required to examine new elements (needles) and techniques like elastography. Elastography helps in the quantification of tissue stiffness with a high level of accuracy. Since 2001, elastography has been applied in diagnosing solid forms of cancer (tumors) that affect organs like the breasts, the thyroid, and some muscles. This method which has been used to diagnose solid pancreatic lesions (SPL) since 2006 has proved to be useful as a complementary method to the existing diagnostic techniques. It improves the accuracy of the endoscopic ultrasound-guided fine-needle aspiration biopsy (EUS-FNA) by selecting the more suspicious area to be punctured, and it also guides the clinical treatment after getting a negative EUS-FNA or a non-conclusive result. Objective: To evaluate the diagnostical performance of the strain ratio (SR) quantitative elastography by ecoendoscopy in solid pancreatic lesions, considering the cytopathologic diagnostic as the gold standard. Methods: 71 patients (age range: 35-89 years old, mean: 62.2 years old); out of those 71 patients, The EUS to diagnose SPL, was performed on 35 women. This was a single-center, prospective cross-sectional study design. The EUS was performed with a Pentax linear endoscope and a Hitachi-Nobilus ultrasound. The lesion (area A) and a reference area B were selected to calculate the deformation ratio (B/A, SR expressed as a percentage). SR > 22 was selected as a cut-off point to determine the malignant lesions (solid lesions), considering the evidence currently available. The results were compared with their cytopathology interpretation once that the EUS was performed. After the exclusion criteria was applied, a statistical analysis of 56 patients was performed, considering p < 0.05. The sensitivity, the specificity, the positive predictive value (PPV), the negative predictive value (NPV) and the diagnostic accuracy, were calculated, comparing the elastography SR with the final diagnosis with the cytopathologic interpretation. Results: Quantitative elastography SR (%) allows to detect the malignant SPL with sensitivity 94.6% (95% confidence interval [CI]: 85.4%-98.2%), specificity of 89.3% (CI 95%: 78.5 %-95.0%), PPV of 89.8% (CI 95%: 79.5%-95.3%); NPV of 94.3% (IC 95%: 84.6%-98.1%) and an accuracy of 92.0% (CI 95%: 85.4 %-95.7 %). Conclusion: SR quantitative elastography by Endoscopic Ultrasound, EUS is a suitable complement method that improves the EUS-FNA accuracy, by selecting the most suspicious area to be punctured, and it also guides clinical treatment after getting a negative EUS-FNA or a non-conclusive result, due to its high sensitivity and specificity levels to diagnose malignant SPL.

Keywords
Elastography, Endoscopic ultrasound, Solid pancreatic lesion, Elasticity, Pancreas.

INTRODUCTION
The insertion into clinical practice of endoscopic ultrasonography (EUS) has allowed advancing the treatment of a wide range of pathologies, significantly changing their diagnosis or management in 25%–50% of the cases1,2. In the pancreas, EUS obtains high-resolution images of the parenchyma and duct, so it is considered a method for...
staging and diagnosing various entities, whether benign or malignant pancreatic diseases. Its role in the differential diagnosis of solid pancreatic lesions (SPL) stands out, representing a heterogeneous group of entities classified as neoplastic or non-neoplastic. Ductal adenocarcinoma is the most frequently detected malignant tumor, with up to 90% of all neoplastic pancreatic malignancies\(^{3,4}\).

Pancreatic cancer is a significant cause of mortality with a 5-year survival rate of less than 5%, reaching 20% in selected patients (non-invasive tumors undergoing surgical resection)\(^{5}\). EUS cannot always provide an accurate diagnosis using only images despite its demonstrated usefulness. So, obtaining tissue from the pancreas using endoscopic ultrasound-guided fine-needle aspiration (EUS-FNA) offers a good final diagnostic yield\(^{3,6,7}\), a sensitivity of approximately 85%–90%, false negatives of 15%, and specificities close to 100%\(^{7,8}\).

However, several factors substantially affect its yield since it is a demanding procedure from a technical point of view that may require multiple punctures to obtain a sufficient sample and make an adequate diagnosis\(^9\). Other factors that also affect it include interobserver variability, a non-standard technique, the endoscopist’s experience, the position of the equipment, the time of day, the needle gauge used, the technique, the characteristics of lesions, the number of needle passes, the presence of the cytologist in the room, chronic pancreatitis, among others\(^{10-17}\). Therefore, new non-invasive methods have emerged to characterize these lesions more accurately, while EUS-FNA is limited to patients with highly-suspected malignant lesions. One of these techniques is elastography\(^{1,18}\), a non-invasive procedure emerging from the concepts that have been described since 1988, such as tissue deformability and elasticity of a solid tumor\(^{19}\). Later, in 1991, tissue elasticity was measured by evaluating a modulus of elasticity after exerting pressure. The term elastography was then used for the first time\(^{20,21}\), resulting in real-time B-mode ultrasound imaging development in 2001\(^{21,22}\). Since then, elastography has been applied to the diagnosis of solid tumors in various organs, such as the breast, thyroid, lymph nodes, and liver, but the use of elastography for SPL was reported for the first time in 2006\(^{21,23,24}\).

From a technical point of view, elastography is founded on the fact that the pressure exerted on a target lesion by an endoscopic ultrasound probe creates strain, which differs according to the hardness or softness of the tissue. So, it allows distinguishing the tissues considered benign—soft—from those malignant—hard. The strain created in the tissues is represented through different colors based on elasticity (red is the softest tissue, and blue is the hardest tissue)\(^{21,25}\). There are two elastography systems available. The first is grounded on the qualitative assessment of the pattern obtained from the elastographic study (qualitative elastography: If the color of the lesion is homogeneous blue, it suggests malignancy). The second quantifies stiffness using software (quantitative elastography)\(^{1,25}\). The most crucial advantage of EUS elastography is that it can provide the endoscopist with real-time data during diagnostic evaluation, assessing the nature of the patient’s lesion and targeting it more accurately when taking the cytology sample by EUS-FNA, without a second endoscopic stage or additional diagnostic studies. It is noteworthy that EUS elastography is not yet considered a technique to replace biopsy. It may be a helpful complement since it improves the accuracy of the EUS-FNA biopsy by selecting the most suspicious area for puncture and guides further clinical management when EUS-FNA is negative or inconclusive\(^{18,25}\).

In Colombia, no clinical studies have shown the diagnostic yield of EUS elastography in SPL; therefore, this study evaluates the diagnostic yield of quantitative elastography or strain ratio (SR) in differentiating SPLs.

**MATERIALS AND METHODS**

**Primary objective**

To evaluate the diagnostic yield of the quantitative SR elastography obtained by EUS in SPLs using histopathological diagnosis as a standard.

**Study design**

This prospective cross-sectional study was conducted between January 2017 and January 2018 in a benchmark gastroenterology and endoscopic ultrasound unit. The unit’s ethics committee approved the study, carried out under the Declaration of Helsinki and its amendments, and Good Clinical Practice guidelines\(^{26}\).

**Patients**

A total of 682 endoscopic ultrasounds were performed in this period, of which 71 (10.56%) were patients referred for SPL puncture. We selected this group of patients considering the following inclusion criteria: patients older than 18 years of age with a diagnosis of SPL, endoscopic ultrasound report that included quantitative SR elastography and EUS-FNA, conclusive results of the cytopathology from puncture samples, and signed informed consent. The exclusion criteria were patients with performance status greater than 4 on the ECOG (Eastern Cooperative Oncology Group) scale (Table 1)\(^{27}\), patients with bleeding risk (international normalized ratio [INR]) > 1.5 or platelet count < 50,000/mm\(^3\), patients who take two or more
color Doppler ultrasound system (Hitachi Aloka Medical, Tokyo, Japan), including the elastography module, by an endoscopist experienced in interventional procedures, with more than 1,500 puncture endoscopic ultrasound procedures performed. Also, 22-gauge endoscopic ultrasound aspirating needles (Boston Scientific) were used. According to the recommendations in the literature, the wet suction technique was employed to take biopsies, with a total of five passes and four motions within the lesion, given its higher diagnostic yield (85.2%) compared to the dry technique (71%) in our population (results to be published). In this technique, before puncturing the lesion, the stylet (22-gauge needle) is removed and pre-washed with 5 mL of saline solution to replace the air column with liquid. A 10 mL syringe is prefilled with 3 mL of saline solution and employed for subsequent aspiration when puncturing the lesion. Once the needle is inside, it is moved three times from one side to the other; this maneuver is repeated four times (passes) for a total of 12 motions. When the needle is withdrawn, the aspirate is released into a sheet by applying air. In addition to the higher diagnostic yield, a meta-analysis showed a lower rate of bleeding with this technique. The samples were fixed in ethyl alcohol and sent for cytopathological study by a pathology specialist.

Table 1. ECOG Performance Status

<table>
<thead>
<tr>
<th>Grade</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Fully active, able to carry on all pre-disease performance without restriction</td>
</tr>
<tr>
<td>1</td>
<td>Restricted in physically strenuous activity but ambulatory and able to carry out work of a light or sedentary nature, e.g., light housework, office work</td>
</tr>
<tr>
<td>2</td>
<td>Ambulatory and capable of all selfcare but unable to carry out any work activities; up and about more than 50% of waking hours</td>
</tr>
<tr>
<td>3</td>
<td>Capable of only limited selfcare; confined to bed or chair more than 50% of waking hours</td>
</tr>
<tr>
<td>4</td>
<td>Completely disabled; cannot carry on any selfcare; totally confined to bed or chair</td>
</tr>
<tr>
<td>5</td>
<td>Dead</td>
</tr>
</tbody>
</table>

Taken from reference(27).

antiplatelet agents, patients with a pancreatic mass that cannot be detected by EUS, patients in whom puncture is not achievable due to anatomical variants (interposition of large vessels, altered surgical anatomy), pregnant women, patients under 18 years of age, and patients who did not authorize the inclusion of their data in the study. After following the criteria, we included 56 patients for analysis.

Statistical analysis

A fellow gastroenterology internist previously trained collected data from the included population through Google Drive virtual data tables filled in simultaneously with the procedure; these data were corrected and entered in the SPSS software (version 12.0; SPSS Inc.). SR data were tested using one-way analysis of variance, considering a p-value < 0.05 to indicate statistical significance. We present data as means, ranges, percentages, and 95% confidence intervals (CI), as appropriate. Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and accuracy were calculated by comparing the diagnoses made by SR elastography and the final diagnoses provided by cytopathology, obtained through EUS-FNA.

Technique

EUS in all patients followed the quality indicators of the American Society for Gastrointestinal Endoscopy and the American College of Gastro-enterology(28). They were carried out in the gastroenterology ward of a benchmark unit under anesthesiologist-guided sedation, with a combination of propofol and remifentanil titrated according to the characteristics of each patient. All procedures were performed with a Pentax linear echoendoscope (EG3870UTK; Pentax, Tokyo, Japan) combined with a Noblus portable color Doppler ultrasound system (Hitachi Aloka Medical, Tokyo, Japan), including the elastography module, by an endoscopist experienced in interventional procedures, with more than 1,500 puncture endoscopic ultrasound procedures performed. Also, 22-gauge endoscopic ultrasound aspirating needles (Boston Scientific) were used.

According to the recommendations in the literature, the wet suction technique was employed to take biopsies, with a total of five passes and four motions within the lesion, given its higher diagnostic yield (85.2%) compared to the dry technique (71%) in our population (results to be published). In this technique, before puncturing the lesion, the stylet (22-gauge needle) is removed and pre-washed with 5 mL of saline solution to replace the air column with liquid. A 10 mL syringe is prefilled with 3 mL of saline solution and employed for subsequent aspiration when puncturing the lesion. Once the needle is inside, it is moved three times from one side to the other; this maneuver is repeated four times (passes) for a total of 12 motions. When the needle is withdrawn, the aspirate is released into a sheet by applying air. In addition to the higher diagnostic yield, a meta-analysis showed a lower rate of bleeding with this technique. The samples were fixed in ethyl alcohol and sent for cytopathological study by a pathology specialist.

For evaluating elastography, elasticity values were marked with different colors, resulting in different elastographic patterns that were superimposed on conventional B-mode EUS images, following the technical recommendations available in the literature published so far(25,33). As a result, the color representation of hard, intermediate, and soft tissues was blue, green/yellow, and red, respectively. The linear echoendoscope was maneuvered towards the gastrointestinal lumen, administering the necessary strain to generate an optimal B-mode image at 7.5 MHz for elastography. The region of interest (ROI) for the elastographic
examination was chosen manually to cover the entire target area of the SPL (or most of it when the dimensions of the lesion did not allow it) and the surrounding tissues. The study required a five-second stable image for quantitative analysis and final definition of the pattern.

Two different ROI areas (A and B) were selected for quantitative elastographic analysis. Area A includes the entire lesion (when possible), while Area B includes the reference peripancreatic fatty area outside the tumor (fatty soft tissue)\(^{(25,33,34)}\). SR was calculated by the processor software expressed as a percentage, considering the ROIs, and calculating the B/A ratio\(^{(25,35)}\). We estimated their elasticity values three times in all patients to limit the selection bias of Areas A and B; the mean value of the three SR measures was deemed the analysis result. Values > 22 were taken as the cut-off point for SR to define malignant (hard) lesions, per the published data on the differential diagnosis of SPL, especially the cut-off point recently identified in a study carried out in 398 patients using SR values to detect pancreatic cancer. Specifically, they were 21.80 ± 12.23\(^{(36)}\), a cut-off point similar to that found by Itokawa \textit{et al}, and 39.08 ± 20.54\(^{(37)}\). The published recommendations on the technique were considered\(^{(25)}\).

**RESULTS**

A total of 682 endoscopic ultrasounds were performed between January 2017 and January 2018; 71 patients (10.56\%) in an age range of 25-89 years (mean: 62.28 years) were diagnosed with SPL. The size of the evaluated lesions ranged between 15 and 60 mm (mean: 29.34 mm); the SR range (%) obtained was 12-189 (mean: 51.15). On the one hand, of these patients, 35 (49.3\%) were female, in an age range of 25-89 years (mean: 63.32 years); the size of the lesion in this group was 15-55 mm (mean: 30.804\,), and the SR range (%) was 13-189 (mean: 50.436). On the other hand, 36 (50.7\%) patients were male, in an age range of 29-87 years (mean: 61.24\,); the size of the lesions in this group was 15-60 mm (mean: 27.97 mm), and the SR range (%) was 12-140 (mean: 51.86) (\textit{Table 2}).

The puncture was performed in 100\% of the patients, but in 11 (6 women and 5 men [15.5\%]), the samples were not enough for pathology to reach a diagnostic conclusion. Two (2.8\%) of the female patients did not give their authorization for the study, and we could not contact 2 patients (male and female; 2.8\%) to know the results of the histopathological study. Statistical analysis was made on 56 patients, 24 females (42.8\%) and 32 males (58.2\%) (\textit{Figure 1}). The endoscopic ultrasound diagnoses, their frequency, and the diagnoses found later in the histopathological study are summarized in \textit{Table 2}.

When performing the statistical analysis, we found that SR quantitative elastography (%) allows detecting malignant pancreatic masses with a sensitivity of 94.6\% (95\%CI: 85.4-98.2), specificity of 89.3\% (95\%CI: 78.5-95.0), PPV of 89.8\% (95\%CI: 79.5-95.3); NPV of 94.3\% (95\%CI: 84.6-98.1), and accuracy of 92.0\% (95\%CI: 85.4-95.7).

**DISCUSSION**

The prevalence of SPL is not as apparent. Strang \textit{et al} reported a 0.6\% prevalence of pancreatic masses in potentially healthy kidney donors\(^{(38)}\); a similar prevalence of 0.49\% was found among 2,941 patients undergoing 18F-fluorodeoxyglucose positron emission tomography (FDG-PET) for unrelated causes\(^{(39)}\). In Japan, of 39,785 FDG-PETs performed for cancer detection, the prevalence of pancreatic neoplasia was less than 0.001\%\(^{(40)}\), a figure more closely related to SEER (Surveillance, Epidemiology, and End Results program, United States), showing an overall incidence of 0.73\% for 2013, which has increased\(^{(41)}\.

The differential diagnosis of SPLs is broad since they represent a heterogeneous group of entities classified as neoplastic and non-neoplastic. Neoplastic lesions (also called malignant) are the most common and include adenocarcinoma, neuroendocrine tumors, solid pseudopapillary tumor, pancreatoblastoma, lymphoma, metastases, and miscellaneous rarer neoplasias\(^{(42,43)}\). As mentioned, ductal adenocarcinoma is the most common malignant tumor of the pancreas and represents about 90\% of all pancreatic...
On physical examination, jaundice, muscle wasting, skin lesions, palpable lymphadenopathy, hepatomegaly, or palpable masses may be found. These lesions are sometimes found incidentally on control abdominal imaging, during the evaluation of abdominal pain, or in patients who present abnormalities on routine or diagnostic liver profiling tests. Remarkably, the increased levels of bilirubin and alkaline phosphatase may result in a diagnosis of cholestasis.

<table>
<thead>
<tr>
<th>Table 2. Characteristics of the Patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex</td>
</tr>
<tr>
<td>----------------------------------------</td>
</tr>
<tr>
<td>Female</td>
</tr>
<tr>
<td>Male</td>
</tr>
<tr>
<td>Total</td>
</tr>
</tbody>
</table>

Endoscopic ultrasound diagnosis
- Cancer in the head of the pancreas | 51 | 71.8 |
- Cystadenocarcinoma | 1 | 1.4 |
- Injury to the head and body of the pancreas | 2 | 2.8 |
- Injury to the body of the pancreas | 4 | 5.6 |
- Focal injury to the head of the pancreas | 6 | 8.4 |
- Chronic pancreatitis | 2 | 2.8 |
- Frantz’s tumor | 2 | 2.8 |
- Cancer in the tail of the pancreas | 2 | 2.8 |
- Injury to the neck of the pancreas | 1 | 1.4 |
- Total | 71 | 100 |

Histopathological diagnosis
- Adenocarcinoma | 48 | 67.6 |
- No diagnosis | 15 | 21.1 |
- Chronic pancreatitis | 4 | 5.6 |
- Solid pseudopapillary tumor | 2 | 2.8 |
- Mesenchymal lesion with atypia | 1 | 1.4 |
- Oncocytic papillary neoplasia | 1 | 1.4 |
- Total | 71 | 100 |
- Do not meet the criteria for analysis | 15 | 21.1 |
- Total patients included in the statistical analysis | 56 | 78.9 |

malignant neoplasias\(^{3-5,44,45}\). The American Cancer Society estimates that 48,960 cases of pancreatic cancer developed in 2015 in the United States, and most patients (40,560) will die of the disease\(^{46}\). The 5-year survival rate is less than 5%, reaching its highest point (20%) in selected patients with non-invasive tumors who underwent surgical resection\(^{47}\).

Symptoms generally do not occur until the disease is advanced and frequently presents with obstructive jaundice, abdominal pain, anorexia, weight loss, acute pancreatitis, onset or poorly controlled diabetes, or steatorrhea. On physical examination, jaundice, muscle wasting, skin lesions, palpable lymphadenopathy, hepatomegaly, or palpable masses may be found. These lesions are sometimes found incidentally on control abdominal imaging, during the evaluation of abdominal pain, or in patients who present abnormalities on routine or diagnostic liver profiling tests. Remarkably, the increased levels of bilirubin and alkaline phosphatase may result in a diagnosis of cholesta-
sis due to biliary obstruction when the SPL is in the head of the pancreas; however, most patients present it without any symptoms, so the main objective is to detect it in its early stages. Currently, ultrasound, computerized axial tomography (CAT), and magnetic resonance imaging (MRI) are the mainstay in assessing 80%–85% of SPLs.

The challenge of preoperative diagnosis of SPLs persists despite advances in imaging. EUS-FNA is considered the method of choice to detect and diagnose these lesions, but multiple factors affect its yield, driving the development of new diagnostic methods based on technological advances, such as elastography. The latter has been used successfully in examining organs other than the pancreas, such as breast, thyroid, prostate, cervix, liver, muscles, and others.

Elastography is based on the knowledge that different pathologies trigger processes such as fibrosis and inflammation, increasing the rigidity of tissues. Physiological vascular pulsations and respiratory movements provide the necessary vibrations and compressions that the software takes for the study; thus, elastography is built to mainly use the information from the aortic pulse wave. Elastography can be performed in real-time using conventional endoscopic ultrasound equipment connected to a processor with specific software installed. It is deemed an easy-to-use technique when performing an endosonography; it does not require additional preparation or changes in the patient’s position or the anesthetic procedure.

There are two different generations in EUS elastography; the first generation allowed only qualitative assessment. Using this, Giovannini et al. published the first study on EUS-guided elastography in SPL. The sensitivity and specificity were reported for malignancy of 100% and 67%, respectively, considering the blue (hard) lesions as malignant. This study defined a scoring system (Table 3) to classify elastography less subjectively. In 2009, Giovannini et al., in a multicenter study with 121 cases, reported that EUS elastography in differentiating between benign and malignant pancreatic masses reached a sensitivity of 92.3%, with a specificity of 80.0%, PPV of 93.3%, NPV of 77.4%, and overall accuracy of 89.2%. Published that same year, Iglesias-García et al. evaluated 130 patients with solid pancreatic masses and 20 controls, defined four different elastography patterns, and reported a sensitivity of 100%, specificity of 85.5%, PPV of 90.7%, NPV of 100%, and accuracy of 94.0%. All subjects were evaluated by two endosonographers who made the same interpretation in 121 of 130 cases and 20 of 20 controls, with a 0.772 kappa index as a consistency evaluator. By 2015, Soares J-B et al. appraised the interobserver consistency and concluded that EUS-guided elastography is reproducible in SPL assessment, even among inexperienced or little experienced echoendoscopists.

Currently, second-generation EUS elastography and qualitative assessment enable quantitative estimation of tissue stiffness with two different approaches: SR and strain histogram. SR is the most widely disseminated with the largest number of studies, for which it was taken as the base criterion of the study; SR compares the strain between target area A and other reference areas B to provide more objective qualitative data. Multiple studies use SR to diagnose pancreatic carcinoma differentially. All of them have variants in taking the areas of interest to ROI; some take healthy pancreatic tissue, peripancreatic tissue, and mesenteric fat, and others take the duodenal wall as a reference to obtain SR. In our study, peripancreatic fat was used to compare lesions (ROI B); it is a soft tissue that can be quickly evaluated in the same image or ultrasound cut given the anatomical proximity of these structures and for being the pattern for breast lesions, with which this technique was initially described.

The diagnostic yield of SR qualitative elastography has been estimated over time in different meta-analyses. In 2012, elastography had a sensitivity of 95% (95%CI: 93–96) and a specificity of 69% (95%CI: 63–75). In 2013, 13 studies were assessed with 1,042 cases and a sensitivity of 95% (95%CI: 94–97), specificity of 67% (95%CI: 61–73), and odds ratio (OR) of 42.28 (95%CI: 26.90-66.46). Also, in 2013, another meta-analysis included seven studies with 752 patients and found that the sensitivity of EUS elastography for the differential diagnosis of solid pancreatic masses was 97% (95%CI: 0.95–0.98), and the specificity was 76% (95%CI: 0.69–0.82). The area under the curve (AUC) was 0.9529. The positive probability ratio was 3.71 (95%CI: 2.72-5.07), and the negative probability ratio was 0.05 (95%CI: 0.02-0.13). Another meta-analysis published in the same year included ten stud-

---

**Table 3. Classification of Elastographic Patterns for EUS**

<table>
<thead>
<tr>
<th>Color and pattern</th>
<th>Rigidity</th>
<th>Malignancy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Homogeneous, green predominates</td>
<td>Soft</td>
<td>No</td>
</tr>
<tr>
<td>Heterogeneous, green predominates</td>
<td>Intermediate</td>
<td>No</td>
</tr>
<tr>
<td>Heterogeneous, blue predominates</td>
<td>Hard</td>
<td>Yes</td>
</tr>
<tr>
<td>Homogeneous, blue predominates</td>
<td>Hard</td>
<td>Yes</td>
</tr>
<tr>
<td>Heterogeneous, green and blue with no predominant color</td>
<td>Hard</td>
<td>Indeterminate</td>
</tr>
</tbody>
</table>

Taken from reference.


dies with a total of 781 patients and reported a sensitivity of 92% (95% CI: 0.89-0.95), specificity of 76% (95% CI: 0.67-0.83), positive likelihood ratio (LR [+] ) of 2.84 (95% CI: 2.05-3.93), negative likelihood ratio (LR [-] ) of 0.12 (95% CI: 0.08-0.19), and diagnostic OR of 24.69 (95% CI: 12.81-47.59) \(^{(74)}\). Nonetheless, all these studies reveal significant heterogeneity due to the variability between controlled clinical trials included, mainly the selection of different ROIs (the soft reference area B). Other factors to consider are the distance of the reference area from the echoendoscope, which also significantly impacts SR measurements\(^{(75)}\), various SR cut-off points, and the subjectivity of qualitative elastography.

More recently, in 2018, a new meta-analysis that included a total of 19 studies with 1,687 patients who underwent quantitative elastography showed a sensitivity of 95% (95% CI: 0.93–0.97), specificity of 61% (95% CI: 0.56–0.66), LR (+) of 2.64 (95% CI: 1.82–3.82), and LR (-) of 0.10 (95% CI: 0.06-0.16) \(^{(76)}\). Our study found a sensitivity of 94.6% (95% CI: 85.4–98.2), matching the sensitivity figures reported in the meta-analyses; however, the specificity was 89.3% (95% CI: 78.5–95.0), which is slightly higher than that reported in the literature. This finding may be due to our patients having more advanced and larger lesions (30 mm on average), significantly increasing the possibility of malignancy (86.9%–93.2%) \(^{(77,78)}\). The age of the patients and the methodology reduced confounding factors previously identified in the literature, such as taking peripancreatic fat for comparison (soft tissue, ROI B), taking the average out of three different SRs in the same patient, using a previously evaluated standard cut-off point (> 22), the experience of the endosonographer, and using more technological equipment. Likewise, the reduction of confounding factors was also achieved by following the recommendations on the technical principles of real-time tissue elastography recently described in detail by the European Federation of Societies for Ultrasound in Medicine and Biology (EFSUMB) and the World Federation of Ultrasound in Medicine and Biology (WFUMB). In summary, these parameters comprise an appropriate transducer and the selection of the adequate frequency, number of frames per second, line density, probing speed and amplitude, noise filters (ultrasonographic), persistence, the dynamic range of elasticity, and other quality parameters (e.g., viewing the deformation graph) \(^{(70,79-81)}\). For its part, the PPV of 89.8% (95% CI: 79.5-95.3), NPV of 94.3% (95% CI: 84.6–98.1), and accuracy of 92.0% (95% CI: 85.4–95.7) are consistent with those found in a recently published retrospective study of 116 patients (97 with malignant lesions and 19 with benign lesions) with a median age of 55.9 years old; an SR cut-off point of 7.75 was used with a specificity of 99.9%, sensitivity of 90.7%, PPV of 99.9%, NPV of 67.9%, and accuracy of 92.2% \(^{(82)}\).

**CONCLUSION**

Differential diagnosis of SPL remains one of the most difficult diagnostic challenges in clinical practice. EUS-FNA is the best method for diagnosing solid pancreatic tumors due to its high sensitivity and specificity when combined with quantitative elastography. However, EUS elastography is not yet considered a modality that can replace biopsy. It is a valuable complement since it improves the accuracy of the EUS-FNA biopsy by selecting the most suspicious area to be punctured. Additionally, it helps guide additional clinical management when EUS-FNA is negative or inconclusive because, as this paper shows, it is highly sensitive and specific in diagnosing malignant tumors of the pancreas.

**REFERENCES**


Utility of quantitative elastography by Endoscopic Ultrasound (EUS) to diagnose solid pancreatic lesions (SPL)


Utility of quantitative elastography by Endoscopic Ultrasound (EUS) to diagnose solid pancreatic lesions (SPL)


