

## ECHOENDOSCOPY – CURRENT SITUATION IN GASTROENTEROLOGY

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### ABSTRACT

Echoendoscopy, endoscopic ultrasound or endosonography is an examination that combines endoscopic and ultrasound images in order to evaluate the lesions found not only in the gastrointestinal tract wall but also around it. This investigation also allows staging patients with gastrointestinal cancer, tumors of the pancreas and lung. Therefore, the indications for endoscopic ultrasound are very broad (some more supported by the literature than others) and their utilities are multiple. The current trend is to move from diagnostic echoendoscopy to a therapeutic one, since it is being used for multiple purposes, such as guiding minimally invasive surgical procedures. A concise review of the literature was made to summarize the applications of endoscopic ultrasound, in order to familiarize gastroenterologists with their indications and possible therapeutic applications. Endoscopic ultrasound (EUS), also known as endosonography (ES) and endoscopic ultrasound (UE), is an examination that combines the endoscopic image with the ultrasound image to evaluate lesions located in and around the wall of the gastrointestinal tract. Although it was described more than 20 years ago, its indications, both diagnostic and therapeutic, remain unknown by the majority of medical specialists or general practitioners. Every day more and more publications about EUS are published, describing new indications of this interesting examination and ratifying those previously

### RÉSUMÉ

**L'écho-endoscopie – situation actuelle en gastro-entérologie**

L'écho-endoscopie, l'échographie endoscopique ou l'endosonographie est un examen qui associe des images endoscopiques et échographiques afin d'évaluer les lésions retrouvées non seulement dans la paroi du tube digestif, mais également autour de celle-ci. Ce test permet également de stadialiser les patients atteints d'un cancer gastro-intestinal, de tumeurs du pancréas et du poumon. Par conséquent, les indications pour l'échographie endoscopique sont très larges (les unes sont plus soutenues par la littérature que les autres) et leurs utilités sont multiples. La tendance actuelle est de passer de l'écho-endoscopie diagnostique à une écho-endoscopie thérapeutique, car elle est utilisée à des fins multiples, comme le guidage d'interventions chirurgicales peu invasives. Une revue concise de la littérature a été faite pour résumer les applications de l'échographie endoscopique, afin de familiariser les gastroentérologues avec leurs indications et les applications thérapeutiques possibles. L'échographie endoscopique (EUS), également appelée endosonographie (ES) et l'échographie endoscopique (UE), est un examen qui combine l'image endoscopique avec l'image échographique pour évaluer les lésions localisées dans et autour de la paroi du tractus gastro-intestinal. Bien qu'il ait été décrit il y a plus de 20 ans, ses indications,

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described, making it an indispensable tool within a gastroenterology service.

**Key-words:** echoendoscopy, endoscopy ultrasound, technique, indications, accuracy.

## INTRODUCTION. INSTRUMENTS AND TECHNIQUE

The EUS uses radial or linear equipment according to the characteristics of the lesion or the needs of the exam. Radial equipment allows an oblique view (which makes endoscopic vision difficult) and a 360-degree ultrasound image. There are frequencies up to 20MHz, which are always located at the tip of the equipment. The radial endosonograph is the most used for diagnostic tests and ultrasound with this equipment identifies five layers in the wall of the entire digestive tract, when performed with the frequencies of 7.5 or 12 MHz<sup>1</sup>:

1. The first hyperechoic layer corresponds to the most superficial part of the gastric mucosa.
2. The second hypoechoic layer corresponds to the deep part of the mucosa that can be correlated with the muscular mucosa.
3. Third hyperechoic layer corresponds to the submucosal layer.
4. Fourth hypoechoic layer corresponds to the muscularis propria.
5. Fifth hyperechoic layer corresponds to the serous or adventitic layer.

When higher frequency transducers are used, echo resolution is greater and up to 9 layers can be observed, mainly detailing the mucosal and muscular layers.

The linear endosonograph works with a frequency of 7.5 MHz and also allows oblique endoscopic vision, but the ultrasound image is only 160 degrees in order to follow the orientation of the puncture needle. In our concept, this is the most complete equipment because it allows not only diagnostic EUS but also therapeutic, since 22G or 19G needles can be used to take biopsies of lesions on the wall or adjacent to it, such as mediastinum, pancreas, adrenal gland etc. Similarly, it is also possible to drain different collections, including those of the bile duct<sup>2</sup>.

The therapeutic possibilities are multiple: fine needle biopsy/aspiration, drainage of pseudocysts, mucosectomy, diagnosis of choledocholithiasis, echoendoscopic cholangiopancreatography, celiac plexus

tant diagnostiques que thérapeutiques, restent inconnues par la majorité des médecins spécialistes ou des médecins généralistes. Chaque jour, de plus en plus de publications sur l'EUS sont publiées, décrivant de nouvelles indications de cet examen intéressant et ratifiant celles décrites précédemment, ce qui en fait un outil indispensable dans un service de gastro-entérologie.

**Mots-clés:** écho-endoscopie, échographie endoscopique, technique, indications, précision.

neurolysis, injecting corticosteroids in stenosis and botulinum toxin in achalasia, intratumoral injection of therapeutic substances, staging of lung cancer.

The endosonographic examination does not differ much in the preparation of upper digestive endoscopy; the patient must have a fast of at least 8 hours and if a therapeutic procedure is going to be performed he must have normal coagulation tests. The patient is placed in left lateral decubitus, with nasal oxygen, monitoring of vital signs and oximetry before starting sedation (propofol/ midazolam). It is important to note that if the ES is diagnostic of the esophagus, stomach or rectum, it can be performed without sedation, given the short time of the examination, if the patient accepts it.

## INDICATIONS

### Cancer

Perhaps the main indication for EUS is the evaluation and staging of patients with cancer of the gastrointestinal tract. For practical purposes, in the digestive tract, from the esophagus to the rectum, the wall is formed by 4 histological layers that in conventional EUS are 5 ultrasound layers which were previously described. The EUS allows to clearly identify these layers and the structures located in their surroundings, which leads to a better preoperative staging of various neoplasms of the digestive tract, surpassing traditional diagnostic methods. The EUS provides a clinical information, difficultly obtainable by other means, in the neoplasms of esophagus, stomach, pancreas, biliary tract, and rectum, modifying the subsequent therapeutic decisions, for which reason it has earned an indisputable place in the strategies of staging and / or monitoring of these diseases.

### Esophageal cancer

The evaluation by ES of patients with esophageal cancer is of fundamental importance for both the squamous type and the adenocarcinoma type. When tumors are limited to the mucosal layer, these are susceptible to endoscopic treatment, through endoscopic

mucosectomy. But in cases of advanced neoplasms, from the locoregional point of view (stages IIB and III), the application of neoadjuvant treatment by the combination of radiotherapy and chemotherapy has been shown to be superior to surgery alone<sup>3</sup>.

Therefore, to classify each patient, within the corresponding treatment group, it is essential to perform the most correct staging at the time of diagnosis of the neoplasm. Classically, multiple studies have demonstrated the superiority of EUS with respect to non-helical CT in the diagnosis of locoregional extension of this neoplasm. In recent years, the appearance of helical CT has shortened these differences, although more recently, the possibility of performing echo guided puncture of the adenopathies has shown that this technique is still superior to classical techniques, even in N staging.

The diagnostic accuracy of EUS for stage T is 75 to 90% and between 70 and 80% for stage N. Some phenomena, such as peritumoral inflammation, can hinder the correct evaluation of the degree of infiltration of the tumor<sup>4</sup>.

What can we identify with endoscopic ultrasound in esophageal cancer that we do not identify with other techniques?

1. Determination of the extension in length of the tumor: the submucosal extension thereof can be underestimated in conventional endoscopy (especially in the lower third and cardial region).
2. Determination of the relationship of the tumor with the carina (supracarinal or infracarinal). This information may have implications in the surgical approach of the neoplasm.
3. Contraindication of surgery in tumors that have invaded neighboring organs (stage T4).
4. Identification of adenopathies, especially those smaller than 1 cm, which are not detected by the CT scan. Also, if indicated, puncture may be performed, with minimal morbidity<sup>5</sup>.

### Gastric cancer

It is important to clarify that there are no ultrasonographic data that allow us to distinguish benign from malignant gastric lesions with sufficient reliability, especially if there are ulcerations, because inflammatory phenomena can have an image identical to neoplastic infiltration. Therefore, endosonographic examination should only be performed after histological confirmation of neoplasia. The exception to this rule occurs in patients with linitis plastica, in whom the endosonographic image is very suggestive and superficial biopsies are usually negative.

EUS has demonstrated its superiority over CT in the diagnosis of locoregional extension of gastric cancer (approximately 85% in the T staging and 80%

in the N), allowing to differentiate if we are dealing with a patient with an early gastric cancer (that is, the lesion only involves the submucosa without infiltrating the muscular layer), which allows endoscopic mucosectomy. In addition, it provides us with valuable information, such as the involvement of neighboring organs (pancreas, left hepatic lobe), or the existence of distant metastatic adenopathies that would require a D3 gastrectomy<sup>6</sup>.

There are some additional difficulties for the correct staging of this neoplasm, such as the impossibility of distinguishing between infiltration of the subserosa (T2) or serous (T3) in the T staging and the frequency of micrometastasis that increases the percentage of error in staging N. The frequent existence of inflammatory phenomena, especially in ulcerated neoplasms, adds difficulty to the exploration, as it has been mentioned previously<sup>7</sup>.

What can we identify with endoscopic ultrasound in gastric cancer that we do not identify with other techniques?

1. Early cancer. EUS is essential to establish whether an injury that is positive for gastric cancer only extends to the submucosa. In these cases it is necessary to use high scanning frequencies, of the order of 12, 15 or 20 MHz.
2. Advanced cancer of the proximal esophagus. EUS is essential to rule out the extension of the tumor to the distal esophagus, which has important therapeutic implications, since it requires an esophagectomy.
3. Evaluation of patients with suspected linitis plastica.

In linitis plastica, neoplastic infiltration confers an important rigidity to the gastric wall due to the fibrous reaction of the submucosa layer, that translates into difficulty to distension with air (endoscopy) or water (EUS). In this pathology, if the echoendoscopic image is typical, it does not usually pose problems and allows to indicate surgery even in the absence of histological confirmation. It presents as a marked thickening of the gastric wall at the expense of all the layers or especially of the submucosa<sup>8</sup>.

### Rectal cancer

The diagnosis and management of rectal cancer have evolved significantly in recent years improving the prognosis of patients. A fundamental aspect in the treatment of this neoplasm is an adequate staging of the pre-therapeutic lesion, given the importance of neoadjuvant treatment. The indications of EUS in other areas of the colon are scarce due to the low incidence of subepithelial lesions since, in the absence of metastases, the locoregional staging of the colon

tumor does not modify the patient's therapeutic management.

Colorectal tumors occur endosonographically in the form of a hypoechoic mass of transmural growth, with or without involvement of the perirectal fat. There are numerous studies that have demonstrated a high precision of endoscopic ultrasound in the diagnosis of TN extension of rectal tumors superior to other techniques of image, like the CT scan. If the lesion is classified as T1, endoscopic mucosectomy or transanal resection is recommended. If it is T2, surgical resection with subsequent radiotherapy is recommended. If it is T3 or T4, preoperative chemoradiation is recommended. The main problem of EUS in the endosonographic interpretation of the images in the rectal neoplasm comes from the peritumoral inflammatory changes that often accompany this neoplasm and that are difficult to distinguish from tumor infiltration<sup>9</sup>.

The value of EUS in the re-evaluation of the response to neoadjuvant treatment is limited, since the inflammatory changes induced by the neoplasm cause significant morphological variations in the rectal wall. On the other hand, it has a prominent role in the detection of early anastomotic recurrences that usually affect the mucosa late, therefore, they are not visualized in conventional endoscopy. For this, it is very important to have a baseline scan that allows comparisons to be made and it is advisable not to practice before 3 months post-intervention<sup>10</sup>.

The usefulness of fine needle aspiration guided by EUS (EUS-FNA) in colorectal neoplasia focuses on the puncture of locoregional adenopathies to confirm its neoplastic nature, especially in those cases in which the patient's management depends of it, as is the case of T2 neoplasms with suspicious lymph nodes. Another very interesting indication of EUS-FNA is the confirmation of para-anastomotic recurrences<sup>11</sup>.

EUS is also useful in confirming the superficial nature of elevated rectal lesions (eg, adenomas), which is essential for successful endoscopic resection. Finally, the EUS can be useful to rule out the involvement of deep layers and the presence of lymphadenopathy in patients in whom the neoplastic character of a polyp removed during an endoscopy is proven. Only the negativity of the base biopsies and the normality of the EUS offer sufficient guarantees to consider that the resection has been oncologically correct.

### **Pancreatic cancer**

This tumor has a poor prognosis not only because of its aggressiveness but because it is diagnosed in advanced stages due to its retroperitoneal location that is not within the reach of most diagnostic tests.

Abdominal CT also has a diagnostic accuracy in the evaluation of the patient with suspicion of a pancreatic tumor with a sensitivity and specificity of 83% and 93%, respectively, and presents evident advantages in the staging of the lesion but the EUS, has a diagnostic performance superior to that of CT, with a sensitivity and specificity of 94 and 100%, respectively. This is how EUS has become the test of choice for the evaluation of patients in whom a mass or lesion of the pancreas is suspected<sup>12</sup>.

The diagnosis of pancreatic cancer should ideally have a cytohistological confirmation before taking a surgical or oncological behavior. For this it is necessary to obtain a sample of tumor tissue, which can be done by fine needle puncture (FNAP) percutaneously, endoscopic, or open biopsy.

In patients with pancreatic masses or hepatic metastases, percutaneous FNAC under ultrasound or CT scanning is the approach that has yielded the highest performance so far, but recent results suggest that endoscopic guided puncture (EUS-FNA), presents a higher performance for cytological confirmation. This technique is especially indicated in unresectable lesions to confirm its neoplastic nature before applying chemotherapy and / or radiotherapy or when certain etiologies are suspected, such as lymphoma, tuberculosis, carcinoids, metastasis, etc. The contraindications of the puncture are the same for invasive procedures.

When there is a high suspicion of pancreatic cancer it is essential to carry out a correct staging of the lesion, in order to establish the most appropriate therapeutic option. For this purpose, traditional tests for the initial diagnosis of this lesion, such as ultrasound or CT, as well as arteriography or abdominal ultrasonography with Doppler recording for evaluation of vascular involvement can be used. The fundamental objective of staging is to establish the resectability of the tumor. In this sense, those lesions that do not affect neighboring structures, such as large vessels (celiac trunk, origin of the hepatic artery, superior mesenteric artery or vein, or portal vein), colon and stomach, and that do not present metastatic dissemination, are considered resectable. It is important to point out that there is no exploration that, by itself, is capable of predicting tumor resectability with absolute certainty. Thus, most authors agree on the need to combine different techniques that provide complementary information or confirm the data in case of discrepancy. A prospective study, which compared the performance of different imaging techniques in the staging of pancreatic cancer, concluded that the combination of abdominal CT with EUS is the most useful approach for predicting tumor resectability. When

both explorations coincide in the unresectability of the lesion, the specificity is 100%<sup>13</sup>.

### GIST

The importance of these injuries is due to the fact that in 30% they can have a malignant behavior and lead to metastasis. The location of these tumors in the different segments of the gastrointestinal tract is as follows: stomach (40-70%), small intestine (20-40%), colon and rectum (5-15%) and esophagus (<5%). As it can be seen, it is an uncommon tumor in the esophagus and therefore, in the presence of a patient with a subepithelial esophageal lesion and that in the EUS a hypoechoic lesion of the fourth layer is observed, it is most likely that it is a leiomyoma; on the other hand, if it is in the stomach, it is most likely a GIST<sup>14</sup>. The majority of patients with this pathology are in the 5th or 6th decade of life and usually the lesion is located in the 4th layer or muscle itself but it can also be located in the muscularis mucosae. Most patients are asymptomatic until the tumor grows enough to ulcerate, bleed or metastasize. When the GIST is greater than 3 cm, surgical treatment is recommended even if it is asymptomatic. Lesions smaller than 3 cm represent a challenge for their management since the vast majority are benign, but it should be clarified that all GISTs have a malignant potential since even small GISTs have been reported with metastases, especially those located in the lower digestive tract. At present it is not possible to accurately predict the malignant potential of a GIST, but the probability is high when the lesion has the following characteristics: diameter greater than 4 cm, irregular borders, cystic spaces in the interior or echogenic foci<sup>15</sup>. Using EUS-FNA, a GIST can be diagnosed by identifying CD-117 and determining its malignant nature if the kit-67 protein is positive, since it indicates proliferation and therefore suggests malignant behavior. Even after a complete resection these tumors can recur in 40% to 90% of cases, mainly at the site of origin but also in the peritoneum or liver<sup>16</sup>.

### Achalasia

Achalasia is an idiopathic esophageal motility disorder characterized by atony of the esophagus, increased pressure, and impaired lower esophageal sphincter relaxation, which is usually thickened. Structural diseases such as tumors of the gastric esophagus, primary, metastatic or amyloidosis can produce a similar clinical picture, called pseudoachalasia. The EUS allows to determine if the picture is due to a pseudoachalasia, to be able to evaluate if there is only thickening of the muscular layer itself or if there is infiltration by another pathology. From

the therapeutic perspective, botulinum toxin is an alternative for elderly patients or patients with high surgical risk making it guided by EUS<sup>17</sup>.

### Adenopathies

The adenopathies that are located in the mediastinum or in the retroperitoneum whose origin is not clear or is not evident, can be evaluated by EUS. Usually, inflammatory lymphadenopathies are less than one cm, irregular and hyperechoic, and malignant adenopathies are rounded, regular, and hypoechoic. However, these characteristics are not always exact and therefore some recommend that, to determine their etiology, guided punctures are performed by EUS, when they are within reach of the puncture needle<sup>18</sup>.

### Choledocolithiasis

Biliopancreatic EUS is one of the main applications of this test. Usually the scan is performed retrogradely by placing the transducer in the third portion of the duodenum and then it is removed progressively; if the examination is complete, the visualization of the pancreas and the extrahepatic bile duct is possible in practically 100% of the patients. On the contrary, there are limitations in the depth of field, so that exploration of the hepatic hilum region is only possible in a quarter of the cases<sup>19</sup>.

Biliopancreatic echoendoscopy has been shown to be superior in terms of precision and diagnostic yield to conventional ultrasound and CT, and at least equal to endoscopic retrograde cholangiopancreatography (ERCP).

Currently, echoendoscopy, cholangio-MR and cholangiography (ERCP or perioperative) are the techniques that have shown greater utility in the diagnosis of choledocholithiasis. In a comparative study between EUS and MR cholangiography performed in a limited number of patients with suspected choledocholithiasis, EUS had a specificity superior to MR cholangiography. In fact, EUS has been shown to be superior to both MRI and ERCP in the diagnosis of microlithiasis. In addition, it should not be forgotten that EUS prevents ERCP not indicated in 87% of cases, as demonstrated in a study with clinical follow-up for one year<sup>20</sup>.

### Neurolysis of the celiac plexus

The control of pain through the neurolysis of the celiac plexus is a technique described many years ago and has traditionally been performed through surgical or radiological routes, however, these accesses have multiple complications. EUS offers a minimally invasive and highly effective access to perform neurolysis, especially in patients with chronic pain from

pancreatic cancer. The location of the celiac ganglia in the root of the celiac trunk is easy due to EUS due to the proximity of this with the gastric wall. This fact allows to place the needle under ultrasound control in the celiac ganglia using an anterior approach and injecting alcohol to obtain a chemical neurolysis. In a pilot study, a block with absolute ethanol was performed in 25 patients with pancreatic cancer and 88% pain improvement was obtained, which lasted on average for 10 weeks. Subsequent reports have shown similar success<sup>21</sup>.

### Pancreatitis

**Acute pancreatitis:** Acute pancreatitis has many etiologies, the most frequent being biliary lithiasis and alcohol, but up to 30% of patients an etiology is not found in its initial assessment. EUS is very useful in the evaluation of these patients because it allows to find stones in the common bile duct and confirm the biliary etiology, in which case it allows to decide the endoscopic intervention. It can also detect tumors, especially in the elderly, or find that the patient is on the basis of chronic pancreatitis. It can also detect early complications of acute pancreatitis such as abscesses or pseudocysts. It is important to clarify that it is prudent to let 4 weeks pass before performing it<sup>22</sup>.

**Chronic pancreatitis:** The EUS has contributed to facilitate its evaluation by allowing to rule out other causes of chronic abdominal pain such as pancreatic cancer. There are endosonographic criteria for chronic pancreatitis that can be divided into parenchymal and ductal criteria. The parenchymal criteria are: decreased echogenicity, loss of the difference between the ventral and dorsal pancreas, hyperechoic foci, hyperechoic bands, atrophy, lobularity. The ductal criteria are: dilation of the main pancreatic duct, hyperechoic wall of the main pancreatic duct, irregular pancreatic duct, visible secondary pancreatic ducts. When the patient has five or more criteria and does not have an episode of acute pancreatitis, there is a high probability that it is a case of chronic pancreatitis<sup>23</sup>.

### Cystic lesions

Cystic lesions, or the content of which is mainly liquid, can be found anywhere in the digestive tract or its adjacent organs such as the liver or pancreas, but it is in the latter organ that they have the greatest clinical relevance. It is very important to differentiate cystic lesions from pseudocysts. The latter has no wall or epithelium and represents the majority of the lesions that we find in clinical practice. The cysts in turn can be divided for practical purposes in:

1. Lesions that have no malignant potential: simple cysts, serous cystadenoma, lymphangioma, cystic teratoma, hemangioma or paraganglioma.

2. Lesions that have malignant potential such as: mucinous cystadenoma, intraductal papillary mucinous tumor (IPMT), pseudopapillary tumor.
3. Malignant lesions such as: cystadenocarcinoma or neuroendocrine tumors that may have cystic presentation<sup>24</sup>.

The EUS allows to distinguish each of these tumors according to their endosonographic characteristics and with the puncture material that can be obtained to study the liquid content.

### ACCURACY OF EUS

Multiple studies have shown that EUS has a high degree of precision in determining if a lesion is from the wall or if it is outside of the wall, and to establish which layer of the wall the lesion is coming from. This information allows us to make a diagnostic approximation. One study determined the source layer in 48 of 50 patients (96%) with surgical correlation. The interobserver agreement is very good, mainly for the identification of lesions such as leiomyomas and vascular lesions. It is important to clarify that the sonographic appearance of the lesions does not allow us to determine its etiology with certainty<sup>25</sup>.

Given that the ultrasound criteria may be inaccurate, it seems reasonable that we should, as far as possible, obtain an etiological diagnosis, which can be achieved with puncture with EUS-FNA, or with mucosal resection of the lesion. Some studies indicate that a tissue diagnosis can be obtained in 50-80% of the cases and the puncture can even identify unsuspected malignant lesions<sup>26</sup>.

In summary, if we face a subepithelial lesion, it is mandatory to perform EUS. If the lesion is small and depends on the echo-layer 1, 2 or 3, a mucosal resection can be performed, which is diagnostic and therapeutic. But if the lesion is large it is ideal to do a guided puncture by endoscopic ultrasound.

### CONCLUSIONS

In conclusion, the indications for endoscopic ultrasound are very broad, some more supported by the literature than others, but it is already a routine test in many gastroenterology centers of the world. The current trend is to move from a diagnostic echo-endoscopy to a therapeutic one (mainly drainage procedures).

#### Compliance with Ethics Requirements:

*„The authors declare no conflict of interest regarding this article“*

*„The authors declare that all the procedures and experiments of this study respect the ethical standards in the*

Helsinki Declaration of 1975, as revised in 2008(5), as well as the national law. Informed consent was obtained from all the patients included in the study“

## REFERENCES

- Lachter J. Basic technique in endoscopic ultrasound-guided fine needle aspiration for solid lesions: what needle is the best? *Endoscopic Ultrasound*. 2014;3(1):46-53.
- Hocke M, Braden B, Jenssen C, Dietrich CF. Present status and perspectives of endosonography 2017 in gastroenterology. *The Korean Journal of Internal Medicine*. 2018;33(1):36-63.
- Rubenstein JH, Shaheen NJ. Epidemiology, diagnosis, and management of esophageal adenocarcinoma. *Gastroenterology*. 2015;149(2):302-317.e1.
- Puli SR, Reddy JB, Bechtold ML, Antillon D, Ibdah JA, Antillon MR. Staging accuracy of esophageal cancer by endoscopic ultrasound: A meta-analysis and systematic review. *World Journal of Gastroenterology: WJG*. 2008;14(10):1479-1490.
- Zuccaro G. The use of endoscopic ultrasound in esophageal disease. *Gastroenterology & Hepatology*. 2007;3(3):163-164.
- Papanikolaou IS, Triantafyllou M, Triantafyllou K, Rösch T. EUS in the management of gastric cancer. *Annals of Gastroenterology : Quarterly Publication of the Hellenic Society of Gastroenterology*. 2011;24(1):9-15.
- Han C, Lin R, Shi H, et al. The role of endoscopic ultrasound on the preoperative T staging of gastric cancer: a retrospective study. Girelli. C, ed. *Medicine*. 2016;95(36):e4580.
- Redondo-Cerezo E, Martínez-Cara JG, Jiménez-Rosales R, et al. Endoscopic ultrasound in gastric cancer staging before and after neoadjuvant chemotherapy. A comparison with PET-CT in a clinical series. *United European Gastroenterology Journal*. 2017;5(5):641-647.
- Siddiqui AA, Fayiga Y, Huerta S. The role of endoscopic ultrasound in the evaluation of rectal cancer. *International Seminars in Surgical Oncology*. 2006;3:36.
- Malmstrøm ML, Säfteiu A, Vilmann P, Klausen TW, Gögenur I. Endoscopic ultrasound for staging of colonic cancer proximal to the rectum: a systematic review and meta-analysis. *Endoscopic Ultrasound*. 2016;5(5):307-314.
- Brown G. Staging rectal cancer: endoscopic ultrasound and pelvic MRI. *Cancer Imaging*. 2008;8(Spec Iss A):S43-S45.
- Bhutani MS, Koduru P, Joshi V, et al. The role of endoscopic ultrasound in pancreatic cancer screening. *Endoscopic Ultrasound*. 2016;5(1):8-16.
- Gonçalves B, Soares JB, Bastos P. Endoscopic ultrasound in the diagnosis and staging of pancreatic cancer. *GE Portuguese Journal of Gastroenterology*. 2015;22(4):161-171.
- Akahoshi K, Oya M. Gastrointestinal stromal tumor of the stomach: how to manage? *World Journal of Gastrointestinal Endoscopy*. 2010;2(8):271-277.
- Igneer A, Jenssen C, Hocke M, et al. Contrast-enhanced (endoscopic) ultrasound and endoscopic ultrasound elastography in gastrointestinal stromal tumors. *Endoscopic Ultrasound*. 2017;6(1):55-60.
- Eckardt AJ, Jenssen C. Current endoscopic ultrasound-guided approach to incidental subepithelial lesions: optimal or optional? *Annals of Gastroenterology: Quarterly Publication of the Hellenic Society of Gastroenterology*. 2015;28(2):160-172.
- Krishnan K, Lin C-Y, Keswani R, Pandolfino JE, Kahrilas PJ, Komanduri S. Endoscopic ultrasound as an adjunctive evaluation in patients with esophageal motor disorders subtyped by high-resolution manometry. *Neurogastroenterology and motility: the official journal of the European Gastrointestinal Motility Society*. 2014;26(8):1172-1178.
- Dietrich CF, Jenssen C, Arcidiacono PG, et al. Endoscopic ultrasound: elastographic lymph node evaluation. *Endoscopic Ultrasound*. 2015;4(3):176-190. doi:10.4103/2303-9027.162995.
- Leszczyszyn J. Choledocholithiasis diagnostics – endoscopic ultrasound or endoscopic retrograde cholangiopancreatography? *Journal of Ultrasonography*. 2014;14(57):125-129.
- Alhayaf N, Lalor E, Bain V, McKaigney J, Sandha GS. The clinical impact and cost implications of endoscopic ultrasound on the use of endoscopic retrograde cholangiopancreatography in a Canadian university hospital. *Canadian Journal of Gastroenterology*. 2008;22(2):138-142.
- Gress F. Endoscopic ultrasound-guided celiac plexus neurolysis. *Gastroenterology & Hepatology*. 2007;3(4):279-281.
- Kotwal V, Talukdar R, Levy M, Vege SS. Role of endoscopic ultrasound during hospitalization for acute pancreatitis. *World Journal of Gastroenterology : WJG*. 2010;16(39):4888-4891.
- Rana SS, Vilmann P. Endoscopic ultrasound features of chronic pancreatitis: a pictorial review. *Endoscopic Ultrasound*. 2015;4(1):10-14.
- Barresi L, Tarantino I, Granata A, Curcio G, Traina M. Pancreatic cystic lesions: how endoscopic ultrasound morphology and endoscopic ultrasound fine needle aspiration help unlock the diagnostic puzzle. *World Journal of Gastrointestinal Endoscopy*. 2012;4(6):247-259.
- Puli SR, Kalva N, Bechtold ML, et al. Diagnostic accuracy of endoscopic ultrasound in pancreatic neuroendocrine tumors: a systematic review and meta analysis. *World Journal of Gastroenterology : WJG*. 2013;19(23):3678-3684.
- Saligram S, Fan F, Oropeza-Vail M, Gholami P, Olyae M. Accuracy of endoscopic ultrasound-guided fine needle aspiration in diagnosing solid pseudopapillary tumor. *North American Journal of Medical Sciences*. 2013;5(12):716-720.