Endoscopic ultrasound (EUS) combines a high-frequency ultrasound probe with an endoscope, and it is now considered an integral part of the management of a variety of gastrointestinal conditions. EUS has been in use since the early 1980s, and is proposed as a safe diagnostic procedure in patients with ARP. The safety and complications of EUS have been evaluated in many studies. In most of the literature, this imaging modality has been shown to be safe with extremely low rates of complications.

EUS is increasingly being performed to evaluate patients with IARP because of high diagnostic accuracy. In a prospective study published in 2000, Liu et al studied 89 consecutive patients with idiopathic acute pancreatitis, and EUS detected cholelithiasis in a large number of patients classified as having idiopathic pancreatitis. The authors concluded that EUS is a valuable diagnostic modality in the management of patients with acute pancreatitis. In addition, published data on the sensitivity of EUS to detect microlithiasis and sludge suggested that this imaging modality has equal or superior sensitivity to other commonly used tests. EUS is a reliable diagnostic method to detect pancreas divisum, occult ampullary mass lesions and pancreatic tumors. Finally, EUS is a useful diagnostic technique to detect the presence of chronic pancreatitis in patients initially diagnosed with idiopathic ARP. This imaging modality is one of the most promising techniques for diagnosis of extension and resectability of pancreatic tumors. It is the most appropriate technique for the assessment of malignancies of the gastrointestinal tract and nearby organs. The most fascinating modification in the field of EUS was the idea of a biopsy needle, which first emerged in 1992. Since then, EUS utilizations have expanded from diagnostic
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Since that date, a wide range of clinical indications for EUS have been found. The main therapeutic purposes of EUS procedure include EUS-guided celiac plexus block, celiac plexus neurolysis, pancreatic tumor ablation, pancreatic pseudocyst drainage and even gallstone extraction.

Endoscopic Retrograde Cholangiopancreatography (ERCP)
ERCP can be used for diagnosis and treatment of a variety of pancreatic disorders. It was first used in 1968, and was soon accepted as a diagnostic technique; in the past decade, it has become exclusively a therapeutic procedure.
There is a documented risk of ERCP-related complications including pancreatitis (1.3%–6.7%), infection (0.6%–5.0%), hemorrhage (0.3%–2.0%), and perforation (0.1%–1.1%) in a prospective series of unselected patients, therefore ERCP should be performed only for limited indications.

Because of the complications of ERCP, many believe that this technique is not indicated after the first episode of pancreatitis for any age groups. By contrast, ERCP has been indicated to evaluate patients with repeated attacks of pancreatitis.

However, ERCP offers some advantages compared with EUS such as potential therapeutic maneuvers, sphincterotomy (either biliary or pancreatic), and the ability to inspect the ampulla, brush and biopsy tissues, aspirate bile fluid or insert a stent.

**Magnetic Resonance Cholangiopancreatography (MRCP)**

MRCP is a non-invasive exploration, which produces detailed images of the hepatobiliary and pancreatic systems. The appearance of MRCP images is considered to be similar to those obtained by ERCP or other invasive methods. Since 1991, MRCP has played an important part in the diagnosis of pancreaticobiliary diseases because of its accuracy, safety and availability. Because MRCP does not require administration of intravenous contrast or ionizing radiation, it is a useful adjunctive tool in almost all patients including infants or those with allergies to iodine-based contrast materials.

MRCP, which has been referred to as “the pancreatogram”, can be used for selecting patients for preoperative ERCP. The diagnostic accuracy of MRCP is considered to be equivalent to that of contrast-enhanced CT in predicting the severity of pancreatitis and identifying pancreatic necrosis. Furthermore, MRCP and ultrasonography have similar sensitivity for detection of gallstones and gallbladder inflammation. MRCP can evaluate pancreatic and peripancreatic cysts, and it is less operator-dependent than ultrasonography or ERCP. On the other hand, unlike ERCP, MRCP does not enable therapeutic maneuvers and it is known to miss gallstones smaller than 4 mm, small ampullary lesions, and ductal strictures.

MRCP is indicated to diagnose pancreas divisum, choledochocle, anomalous pancreaticobiliary junction, or annular pancreas in patients with IARP.

**Comparison of Diagnostic Evaluation: EUS vs ERCP vs MRCP**

Idiopathic recurrent pancreatitis has been diagnosed by ERCP for decades. Over the years, EUS has been used instead of ERCP because of its sensitivity, safety and lower risk of complications. At present, MRCP is gaining wider use as a non-invasive alternative to ERCP to detect the cause of acute pancreatitis in patients with IARP.

EUS has been documented to have a negative predictive value of 95.4% for the diagnosis of CBD stones, and sensitivity of 96% for diagnosing microliths. Several trials have addressed the question of whether EUS is a reliable substitute for ERCP in cases of pancreas divisum. The sensitivity and specificity of EUS need further evaluation in cases of pancreas divisum. Many believe, however, that EUS is an accurate, minimally invasive investigational method for the diagnosis of pancreas divisum.

In 2002, Coyle et al studied 162 patients with pancreatitis to compare the diagnostic utility of ERCP with sphincter of Oddi manometry (SOM), bile analysis, and endoscopic ultrasound. The research showed that EUS is a useful technique to identify the etiology of unexplained acute pancreatitis and tumors. Furthermore, in nine patients suffering from chronic pancreatitis, the condition was detected by EUS but not by ERCP. However, none of the patients with Sphincter of Oddi dysfunction (SOD) was diagnosed by EUS. A similar study from Frossard et al in 2000 reached concordant conclusions. They evaluated 168 patients with idiopathic pancreatitis to compare the usefulness of endoscopic ultrasonography with endoscopic cholangiopancreatography and bile crystal analysis and medical follow-up. In 92% of patients, EUS was able to determine the etiology of idiopathic pancreatitis. The authors stated that EUS can correctly determine the cause of acute pancreatitis in patients initially considered to have idiopathic pancreatitis. Another report by Tandon et al states that EUS can demonstrate the etiology in two-thirds of idiopathic acute pancreatitis cases, and thus can be a less invasive and highly accurate alternative to ERCP.

To compare EUS and MRCP, Forsmark et al enrolled 49 patients initially diagnosed with idiopathic acute pancreatitis in a prospective study. The authors demonstrated that the diagnostic yield of EUS is higher than MRCP in the evaluation of these patients (51% vs 20%). MRCP identified additional features in only 6% of patients in whom EUS could not diagnose the etiology of AP. On the other hand, MRCP outperformed EUS in diagnosing patients who had undergone a cholecystectomy (11% vs 60%). Theyenot et al performed a prospective study with 128 AP patients to compare EUS and MRCP for diagnosing idiopathic acute pancreatitis. The etiology of acute pancreatitis was not found in 41 patients in first line investigation. These patients underwent EUS or MRCP as second line investigation. The authors concluded that EUS had a higher diagnostic yield than MRCP (29% vs. 10.5%).

The diagnostic yield of ERCP in patients with idiopathic pancreatitis varies from 38% to 78%. It is not the preferred first line test for ARP to assess for underlying etiologies because of its associated risk of post-ERCP pancreatitis.

Magnetic resonance cholangiopancreatography is a non-invasive radiographic tool that produces images comparable to those obtained by ERCP, but requires advanced interpretation skills and may not be widely available. The diagnostic yield of MRCP in IARP patients is 22%. Trying to evaluate the usefulness of a new modality to visualize the pancreatic duct in idiopathic ARP, Khalid et al...
Author Contributions
Conceived and designed the experiments: AHMA. Analyzed the data: MTS. Wrote the first draft of the manuscript: MTS. Contributed to the writing of the manuscript: MTS. Agree with the manuscript results and conclusions: MTS. Jointly developed the structure and arguments for the paper: AHMA. Made critical revisions and approved final version: MBM, SE, SS, and AHMA. All authors reviewed and approved of the final manuscript.

REFERENCES
1. Al-Haddad M, Wallace MB. Diagnostic approach to patients with acute idiopathic and recurrent pancreatitis, what should be done? World Journal of Gastroenterology. 2008;14(7):1007.
2. Kaperatos D. Endoscopic management of acute recurrent pancreatitis. Annals of Gastroenterology. 2010;23(1):31–37.
3. Levy MJ, Geenen JE. Idiopathic acute recurrent pancreatitis. The American Journal of Gastroenterology. 2001;96(9):2540–2555.
4. Kedia S, Dhingra R, Garg PK. Recurrent acute pancreatitis: an approach to diagnosis and management. Tropical Gastroenterology. 2014;34(3):123–135.
5. Mekky MA, Abbass WA. Endoscopic ultrasound in gastroenterology: From diagnosis to therapeutic implications. World Journal of Gastroenterology. 2014;20(24):7801.
6. Maple JT, et al. The role of endoscopy in the evaluation of suspected choledocholithiasis. Gastrointestinal Endoscopy. 2010;71(1):1–9.
7. Tandon M, Topazian M. Endoscopic ultrasound in idiopathic acute pancreatitis. The American Journal of Gastroenterology. 2001;96(3):705–709.
8. Liu C-L, et al. EUS for detection of occult cholelithiasis in patients with idiopathic pancreatitis. Gastrointestinal Endoscopy. 2000;51(1):28–32.
9. Dhillon J, et al. Combined endoscopic ultrasound and stimulated biliary drainage in cholecystitis and microlithiasis—diagnoses and outcomes. Endoscopy. 1995;27(6):424–427.
10. Dahlan P, et al. Prospective evaluation of endoscopic ultrasonography and microscopic examination of duodenal bile in the diagnosis of cholecystolithiasis in 45 patients with normal conventional ultrasonography. Gastroenterology. 1996;113(2):277–281.
11. Rana SS, Gonen C, Vilmann P. Endoscopic ultrasound and pancreas divisum. Journal of the Pancreas. 2012;75(3):467–473.
12. Cotton P. Congenital anomaly of pancreas divisum as cause of obstructive pain and pancreatitis. Gut. 1980;21(2):105–114.
13. Wiersma MJ, et al. Endosonography-guided fine-needle aspiration biopsy: diagnostic accuracy and complication assessment. Gastroenterology. 1997;112(4):1087–1095.
14. Rösch T, et al. Localization of pancreatic endocrine tumors by endoscopic ultrasonography. New England Journal of Medicine. 1995;332(26):1721–1726.
15. Teshima CW, Sandhu GS. Endoscopic ultrasound in the diagnosis and treatment of pancreatic disease. World Journal of Gastroenterology. 2004;10(29):9976.
16. Dayyeh BKA, Levy MJ. Therapeutic endoscopic ultrasound. Gastroenterology & Hepatology. 2012;8(7):450.
17. Adler DG, et al. ASGE guideline: the role of ERCP in diseases of the biliary tract and the pancreas. Gastrointestinal Endoscopy. 2005;62(1):1–8.
18. McCune WS, Shorb PE, Moscovitz H. Endoscopic cannulation of the ampulla of vater: a preliminary report. Annals of Surgery. 1968;167(5):752.
19. Anderson MA, et al. Complications of ERCP: Gastrointestinal Endoscopy. 2012;75(3):467–473.
20. Koizumi M, et al. JPN Guidelines for the management of acute pancreatitis: diagnostic criteria for acute pancreatitis. Journal of Hepato-biliary-pancreatic surgery. 2006;13(3):25–32.

Table 1. Studies evaluating EUS, ERCP and MRCP diagnostic rate in patients with IARP.

| METHOD | REFERENCES, YEAR | NO. OF PATIENTS | BILIARY TRACT DISEASE | PANCREAS DIVISUM | TUMOR | CP | IDIOPATHIC | OVERALL YIELD |
|--------|-----------------|-----------------|-----------------------|------------------|-------|----|------------|--------------|
| EUS    | Frossard 2000   | 168             | 103                   | 0                | 4     | 16 | 37         | 78%          |
|        | Tandon 2001     | 31              | 5                     | 2                | 1     | 14 | 10         | 68%          |
|        | Yussoff 2004    | 169             | 46                    | 13               | 1     | 69 | 54         | 68%          |
|        | Rana 2012       | 40              | 20                    | 1                | 1     | 0  | 18         | 55%          |
| ERCP   | Frossard 2000   | 168             | 8                     | 0                | 0     | 16 | 19         | 29%          |
|        | Kaw 2002        | 126             | 8                     | 9                | 2     | 0  | 27         | 79%          |
|        | Fischer 2010    | 1,241           | 37                    | 233              | ND    | 589| 425        | 65.8%        |
| MRCP   | GN Y, 2014      | 50              | 8                     | 1                | 0     | 2  | 39         | 22%          |

Abbreviations: EUS, endoscopic ultrasonography; ERCP, endoscopic retrograde cholangiopancreatography; MRCP, magnetic resonance cholangiopancreatography; CP, chronic pancreatitis; ND, non determined.
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21. Banks PA, et al. Practice guidelines in acute pancreatitis. *American Journal of Gastroenterology*. 2006;101(10):2379–2400.

22. GN Y, et al. The efficacy of magnetic resonance cholangiopancreatography in assessing the etiology of acute idiopathic pancreatitis. *International Journal of Hepato-biliary and Pancreatic Diseases (IJHPD)*. 2014;4:32–39.

23. Barish MA, Yucel EK, Ferrocci JT. Magnetic resonance cholangiopancreatography. *New England Journal of Medicine*. 1999;341(4):258–264.

24. Vrachriotis TG, et al. MR cholangiopancreatography (MRCP). Critical reviews in diagnostic imaging. 1997;38(4):295–323.

25. Hachiya J, Haradome H. [The utilities and outlooks of MR cholangiography (MRCP) as a non contrast and noninvasive technique]. Nihon rinsho. *Japanese Journal of Clinical Medicine*. 1998;56(11):2747–2754.

26. Makary MA, et al. The role of magnetic resonance cholangiography in the management of patients with gallstone pancreatitis. *Annals of Surgery*. 2005;241(1):119.

27. Gossot J, Devière J, Matsos C. Magnetic resonance imaging of acute pancreatitis: the pancreatogram. *JOP*. 2004;5(1):48–50.

28. Carroll JK, et al. Acute pancreatitis: diagnosis, prognosis, and treatment. *Am Fam Physician*. 2007;75(10):1513–20.

29. Napoleon B, et al. Do normal findings at biliary endoscopic ultrasonography obviate the need for endoscopic retrograde cholangiography in patients with suspicion of common bile duct stone? A prospective follow-up study of 238 patients. *Endoscopy*. 2003;35(5):411–415.

30. Amouyal P, et al. Endosonography: promising method for diagnosis of extrahepatic cholestasis. *The Lancet*. 1989;334(8673):1195–1198.

31. Rana SS, et al. Role of endoscopic ultrasound in the diagnosis of pancreas divisum. *Endoscopic Ultrasound*. 2013;2(1):7.

32. Frossard JL, et al. Usefulness of endoscopic ultrasonography in patients with “idiopathic” acute pancreatitis. *The American Journal of Medicine*. 2000;109(3):196–200.

33. Ortega AR, et al. Prospective comparison of endoscopic ultrasonography and magnetic resonance cholangiopancreatography in the etiological diagnosis of “idiopathic” acute pancreatitis. *Pancreas*. 2011;40(2):289–294.

34. Thevenot A, et al. Endoscopic ultrasound and magnetic resonance cholangiopancreatography in patients with idiopathic acute pancreatitis. *Digestive Diseases and Sciences*. 2013;58(8):2361–2368.

35. Khalid A, Peterson M, Slivka A. Secretin-stimulated magnetic resonance pancreaticogram to assess pancreatic duct outflow obstruction in evaluation of idiopathic acute recurrent pancreatitis: a pilot study. *Digestive Diseases and Sciences*. 2003;48(8):1475–1481.

36. Hatano S, et al. Evaluation of MRCP compared to ERCP in the diagnosis of biliary and pancreatic duct. Nihon rinsho. *Japanese Journal of Clinical Medicine*. 1998;56(11):2874–2879.

37. Yusoff IF, Raymond G, Sahai AV. A prospective comparison of the yield of EUS in primary vs. recurrent idiopathic acute pancreatitis. *Gastrointest Endosc*. 2004;60(5):673–678.

38. Kow M, Brodmerkel GJ Jr. ERCP, biliary crystal analysis, and sphincter of Oddi manometry in idiopathic recurrent pancreatitis. *Gastrointest Endosc*. 2002;55(2):157–62.

39. Fischer M, et al. Endoscopic retrograde cholangiopancreatography and manometry findings in 1,241 idiopathic pancreatitis patients. *Pancreatology*. 2010;10(4):444–452.