CLINICAL IMAGING

Intraductal Ultrasonography for the Assessment of Preoperative Biliary and Pancreatic Strictures

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Abstract

Diseases of the biliary and pancreatic ducts are often difficult to diagnose. Although transcutaneous ultrasonograpy, computer tomography and magnetic resonance greatly improved in performance, two major problems have not been completely solved yet: first, the differentiation of malignant and benign bile duct strictures, and, second, the assessment of the resectability of carcinomas underlying biliary strictures. Ultrasound probes can be inserted through the working channel of the duodenoscope and passed selectively both into the biliary and pancreatic ducts. Ultrasound frequencies of 20 or 30 MHz enable a penetration of up to 2 cm and a resolution of 0.07 to 0.18 mm. The main clinical indication for intraductal ultrasonography of the biliary tract is obstructive jaundice, which requires assessment of bile duct strictures and local tumor staging. Miniprobes can contribute to the differential diagnosis of strictures localized in the main pancreatic duct, and also to localizing small endocrine tumors. Small tumors of the papilla of Vater can be staged before a possible endoscopic resection. Feasibility of the method is excellent in expert hands with almost no added morbidity.

Key words

Intraductal ultrasonography – biliary stricture – pancreatic duct stricture.

Introduction

Biliary obstruction may be due to diseases of the bile duct system itself or to diseases of the pancreas. Both diagnosis and surgical treatment of biliary tract diseases have been improved during recent years. However, two problems have not been completely solved yet: first, the differentiation of malignant and benign bile duct strictures, and, second, the assessment of the resectability of carcinomas underlying biliary strictures. Endoscopic retrograde cholangiopancreatography (ERCP) is the most valuable tool for further diagnosis as well as temporary or definitive therapy in patients with biliary strictures [1]. Although the use of endoscopic stenting techniques is very effective in patients with obstructive jaundice, further management of patients primarily depends on the benign or malignant nature of the underlying disease. ERCP provides a unique opportunity to achieve biliary decompression and, simultaneously, to obtain a histological or cytological specimen of the biliary stricture. Although transabdominal ultrasonography (US), computed tomography (CT) and magnetic resonance imaging (MRI) are accurate in diagnosing dilation of bile ducts, the site and extent of primary tumors are more difficult to visualize. Endoscopic ultrasonography (EUS) has been reported to be accurate in staging biliopancreatic tumors [2]. EUS, however, has certain limitations in diagnosing and staging of biliary strictures, particularly in the hepatic hilum. Newly developed ultrasound probes attract special interest as these probes are small enough (diameters of 1.1–2 mm) to be inserted through the working channel of a duodenoscope during ERCP into either the biliary or the pancreatic duct. The probes can be advanced into these structures in a transampullary fashion under fluoroscopic control, or over a guidewire [3]. The mean time for probe insertion and intraductal ultrasonography (IDUS) is 6:30 mins.

The use of ultrasound frequencies of 20 to 30 MHz should theoretically make possible a resolution of 0.07 to 0.18 mm [4].

Indications

The main clinical indication for IDUS of the biliary tract is obstructive jaundice, which requires assessment of bile duct strictures and local tumor staging. Detection of very small stones in patients with dilated bile ducts might be another indication.

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Choledocholithiasis. In patients with persistent pain and dilated bile ducts after cholecystectomy, IDUS might be useful to detect gallstones that are not visualized at ductography [5]. Intraductal sonographic evidence of stones can thus establish the indication for endoscopic sphincterotomy (ESP). Although IDUS has been reported to be superior to ERCP in the detection of bile duct stones (96.8% vs 80.6%), surgically controlled, prospective data are not yet available [6].

Bile duct strictures. Although US naturally does not provide a histopathologic diagnosis, well-known and generally accepted criteria make some tissue characterization possible and thus hint at the underlying disease [7]. High frequency US transducers adapted to the dimensions of the pancreaticobiliary system make IDUS examination possible during ERCP in a single session. The IDUS probe can be passed over under the fluoroscopic control or better over a guidewire placed beforehand. Biliary sphincterotomy is not mandatory for IDUS examination. By visualising the wall layers in biliary strictures and estimating the extent of potentially cancerous infiltration, IDUS may give additional, clinically important information. However, particularly in carcinomas of the bile duct bifurcation and the middle part of the common bile duct, IDUS is superior to EUS in terms of local tumor assessment. Understandably, due to the limited ultrasonic penetration, both systems tend to understage biliary carcinomas in the proximal bile duct and the bile duct bifurcation. Application of higher ultrasound frequencies enhances resolution but reduces depth of penetration. Consequently, IDUS is not suitable for lymph node staging. This problem may be overcome by EUS-guided fine-needle puncture of suspicious lymph nodes [8,9].

The etiology of the majority of biliary strictures is detected with CT, MRI or US. In patients with biliary strictures but no mass visible on CT or MRI, the risk of malignancy is 51 to 70%. Surgical exploration may be required for definite diagnosis. In these patients, IDUS can help establishing the diagnosis [10].

Three layers could be visualized by all examinations, on both the bile duct (BD) and main pancreatic duct (MPD) with a 20 or 30 MHz probe. In the bile duct, the innermost hyperechoic layer corresponds to the bile duct mucosa and bile interface. The middle hypoechoic layer corresponds to the discontinuous fibromuscular layer and the outermost hyperechoic layer - to the subserosal fat (Fig 1).

It is still difficult to differentiate between benign or malignant stenosis only on ultrasound images obtained by IDUS. Benign stenosis tends to be more regulated, less eccentric and hyperecoic (Fig. 2).

As IDUS shows asymmetric bile duct wall thickening due to inflammatory changes as well as cancer, accurate characteristics of the visualized lesion are required. Menzel et al reported that when hypoechoic masses with irregular margins and inhomogeneous echo poor areas invading surrounding tissue on IDUS were considered malignant, the accuracy, sensitivity and specificity of these IDUS findings were 89.1%, 91.1%, and 80%, respectively [9]. If IDUS showed tumour invasion into the hepatic artery, the portal vein, or the pancreatic parenchyma, it suggested malignant disease [11].

Furakawa et al [12] performed IDUS of both the BD and MPD from autopsy specimens of 15 patients in order to provide a basis for interpreting sonograms by comparing them with corresponding histopathological sections. Other studies have suggested that eccentric wall thickening with an irregular surface indicates an underlying malignancy [13, 14] and accuracy in the diagnosis of cholangiocarcinoma in this setting has been reported to be as high as 76% .

As compared with standard EUS, intraductal scanning within the BD stricture itself enhances diagnostic accuracy significantly (89.1% vs 75.6%, p=0.002). Although US does not provide histopathological diagnosis, IDUS yields some specific tissue characterization and thus may direct the diagnostic process to the underlying disease [15]. By virtue of the accepted criteria, miniprobe sonography leads to correct diagnosis in 89% of bile duct strictures.

Tumor staging. Tumor staging relies on precise delineation of the local extent and on detection of lymph nodes and distal metastases to provide a guideline for prognosis and treatment. Due to the limited ultrasonic penetration for both IDUS and EUS, understaging of biliary carcinomas in the proximal bile duct and bile duct bifurcation has been observed [6]. Because of reduced penetrability (less than 2 cm), IDUS is not intended for lymph node staging.

In assessment of local tumor extent, the intraoperative findings were correlated with IDUS and EUS; IDUS was found to be superior to EUS. It correctly diagnosed 76.8% of the carcinomas as compared to 53.6% with EUS (p= 0.001). Particularly in carcinomas of the BD bifurcation and the middle part of the common BD, respectively, IDUS proved to be superior to EUS [16]. IDUS has limited value in assessment of tumor extension outside the hepatoduodenal ligament [1]. However, it can accurately detect tumor invasion into the portal vein or the hepatic artery [9]. Figures

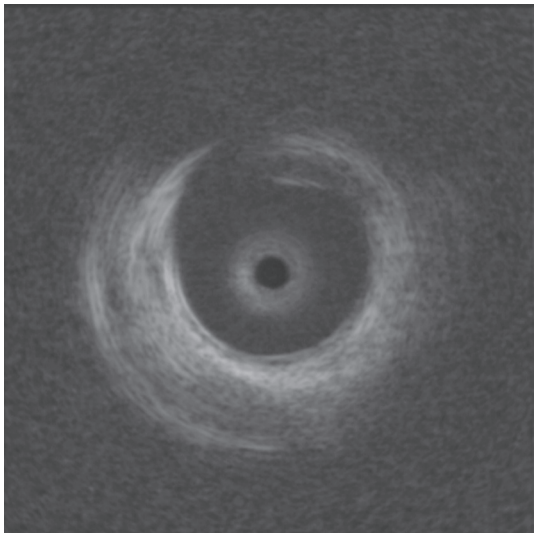

Fig 1. Normal IDUS aspect with three layers of a dilated common bile duct.

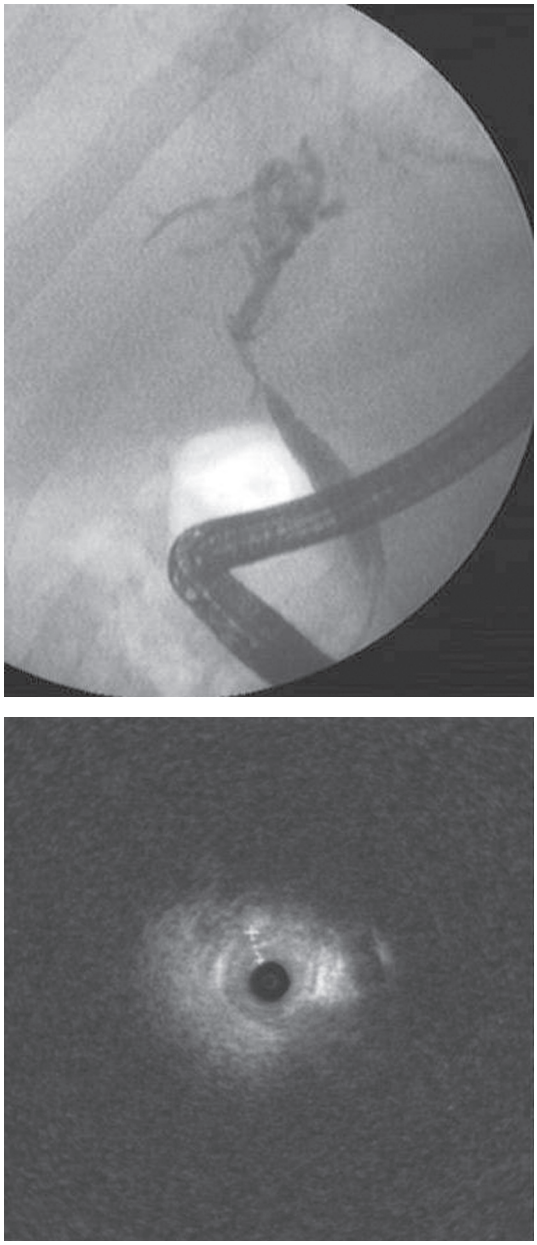

Fig 2: a. ERCP aspect of a secondary posthydatid sclerosing cholangitis; b. IDUS aspect of sclerosing cholangitis with concentric hyperechoic widening of biliary wall, loss of structure, sharp margins.

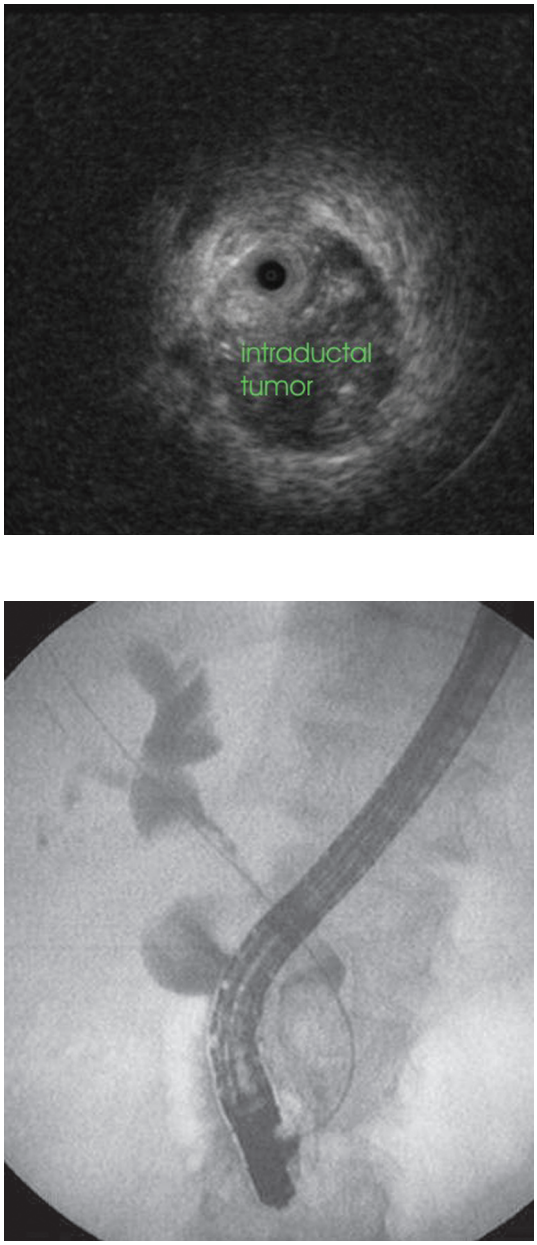

Fig 3: a. IDUS. Hypoechoic mass into the common bile duct corresponding to a polypoid biliary tumor; b. ERCP aspect of the polypoid intraductal tumor.

3 to 9 illustrate different aspects of cholangiocarcinoma examined by IDUS.

Primary sclerosing cholangitis. On IDUS, primary sclerosing cholangitis (PSC) presents with an irregularly thickened wall exhibiting a concentric, onion-shaped pattern. In PSC, suspect inhomogenous areas may be located by means of IDUS, thus allowing selective endoscopic transpapillary or cholangioscopic biopsies. Transpapillary IDUS significantly increases the ability to distinguish malignant from benign dominant bile duct stenoses in patients with PSC [18].

Diseases of the pancreas. In the pancreas, IDUS may be useful in detecting carcinoma in situ and small tumors [19] (Fig. 10), as well as determining invasion in mucin producing tumors [20]. Possible clinical indications for IDUS of the pancreas include: 1) diagnosis of pancreatic duct strictures; 2) local tumor staging and 3) localization of islet cell tumors negative on EUS.

1) Pancreatic duct strictures. In a series of 26 patients, Furukawa et al found IDUS to be superior to EUS, CT and ERP in differential diagnosis of strictures localized in the main pancreatic duct (14 carcinomas, 12 strictures due to chronic pancreatitis) [21]. The sensitivity and specificity, respectively, were: for IDUS: 100%, 91.7%; for EUS: 92.9%, 58.3%; CT: 64.3%, 66.7%; for ERP: 85.7%, 66.7%.

2) Local tumor staging. Data regarding the performance of

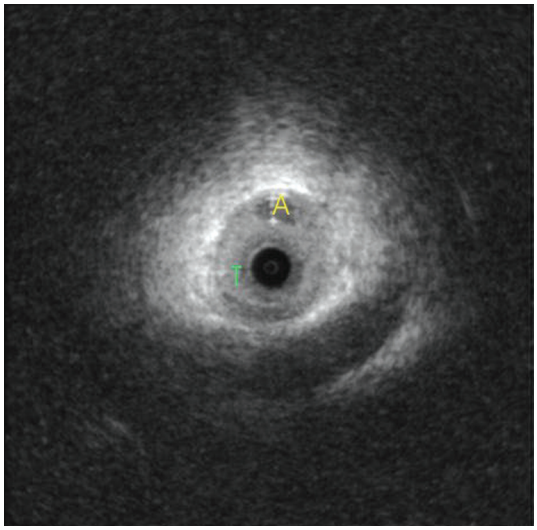

Fig 4. IDUS. Infiltrative tumor with a hypoechoic well delineated zone, corresponding to a small abscess (A).

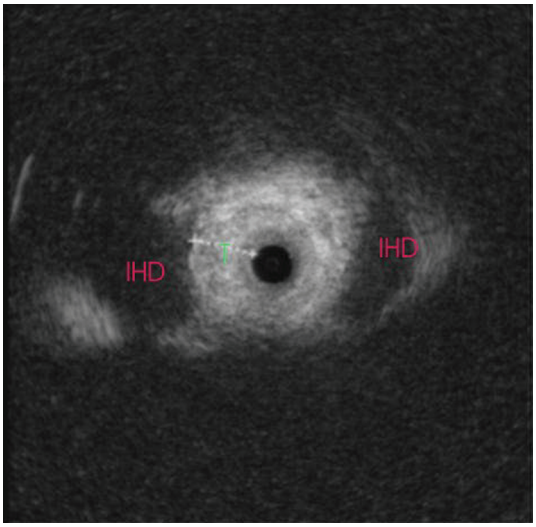

Fig 7. IDUS. Infiltrative hilar tumor. IHD = dilated intrahepatic ducts.

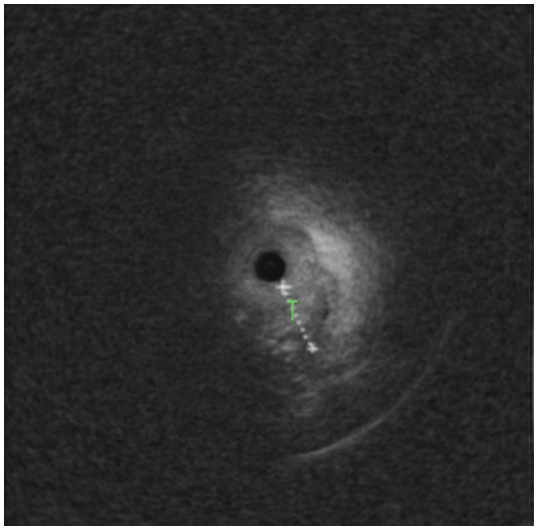

Fig 5. IDUS. Infiltrative eccentric tumor.

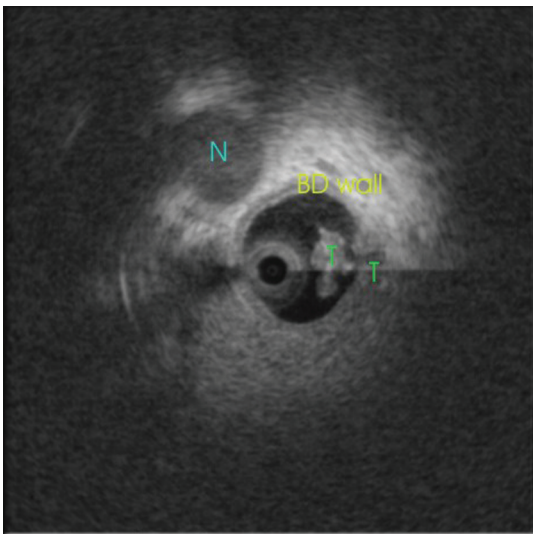

Fig 8. IDUS. Tumor (T) with small adjacent metastasis (N).

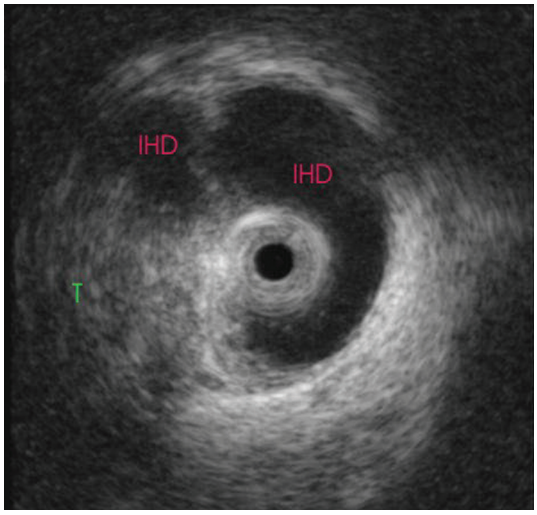

Fig 6. IDUS. Tumor at the hepatic hilum (IHD = dilated intrahepatic ducts).

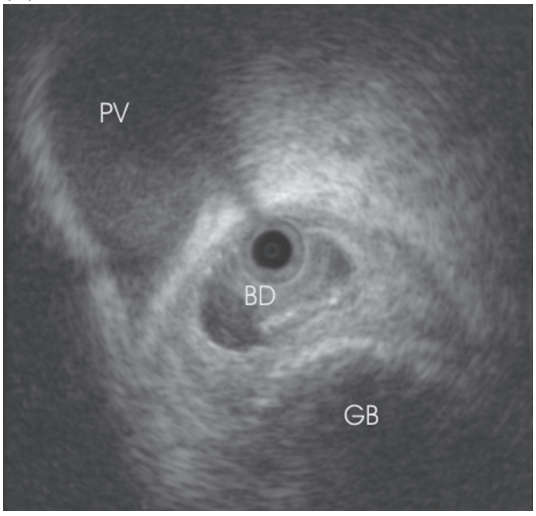

Fig 9. IDUS. Compression of the common hepatic duct (BD) by a distended gall bladder (GB). PV= portal vein.

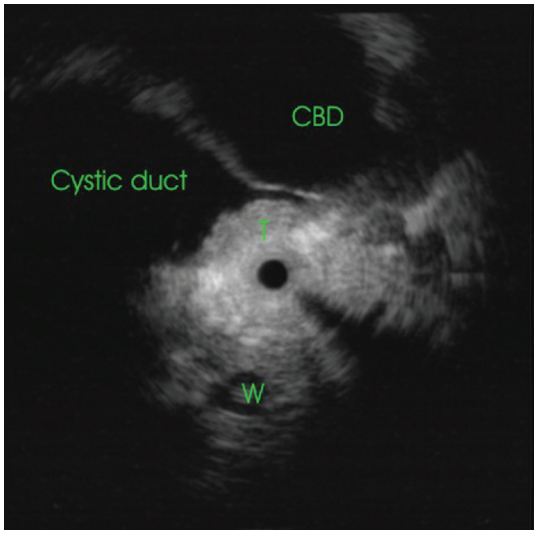

Fig 10. IDUS showing invasion by a pancreatic tumor of the junction of the cystic duct with the common bile duct.

IDUS in local pancreatic cancer staging are not yet available. This might be due to the fact that small pancreatic carcinomas without ductal obstruction are mostly asymptomatic.

3) *Localization of islet cell tumors* negative on EUS. Ultrasonographic frequencies of 15–20 MHz, as well as intraductal scanning, may contribute to the improvement of diagnostic success rates. In patients with suspected pancreatic endocrine tumors that cannot be visualized by conventional imaging techniques including EUS, IDUS may become a valuable method for preoperative tumor localization.

Tumors of the papilla of Vater. IDUS was shown to be able to visualize exactly the anatomy of the papilla of Vater and only IDUS can depict Oddi's muscle as a hypoechoic layer [22]. The value of IDUS, EUS, and CT in determining tumor diagnosis and tumor staging according to the TNM classification has been assessed [23] and shows that IDUS is the single most accurate imaging method to diagnose benign and malignant tumors of the papilla of Vater .

Safety

There are no incremental risks related to IDUS over conventional endoscopy. There are no safety data in the use of IDUS for the evaluation of the pancreatico-biliary tree, although pancreatitis was reported in 3/204 (1.5%) patients in one study [24] and 1/239 (0.4%) in another study [25].

Future technology

Both Olympus and Fujinon are developing 3D scanning probes. They move spirally and obtain 40-120 slices of radial images/ minute. The 3D images are then composed by computer processing.

Conclusion

Intraductal ultrasonography is feasible, easy to perform and in selected cases can bring useful data for the management of the biliary and pancreatic pathology. It is still a technique reserved for specialised centers.

Conflicts of interest

None to declare.

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