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An overview of novelties in endoscopic treatment of the bile ducts

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Abstract

The methods used in the diagnosis and treatment of bile duct diseases - ERCP and EUS - are among the most complex procedures in modern medicine. New technologies make it possible to increase the safety and precision of endoscopic procedures. Technical innovations aim to improve image quality through features such as TXI, RDI, DFI-EUS, and LER. In addition, new tools are being developed for use during endoscopy - Tornus ES and the Hanarostent Z-EUS IT stent.

Key words: bile ducts, gallstones, endoscopy, ERCP, EUS, TXI, RDI, DFI-EUS, LER, EUS-BD, tornus ES, LAMS.

Introduction

Diagnostics and therapy of the bile ducts are one of the most complicated procedures faced by modern medicine. Human anatomy is largely responsible for this state of affairs, but it is nevertheless a driving force for the development of innovative endoscopes and endoscopic

accessories. Technical progress consists mainly in the improvement of the methods used so far – endoscopic retrograde cholangiopancreatography, otherwise known as ERCP and endoscopic ultrasonography (EUS) (Wiercińska 2022).

Endoscopic retrograde cholangiopancreatography (ERCP) is a diagnostic method that combines both endoscopic and X-ray techniques. It is one of the most effective methods for assessing the bile ducts and pancreatic ducts. It is used both in the diagnosis of, m.in jaundice, iatrogenic bile duct damage and the diagnosis of bile duct cancer, as well as a therapeutic method for removing deposits from the bile and pancreatic ducts, putting on prostheses and widening the bile ducts and taking specimens. However, it should be remembered that ERCP is an invasive test that can lead to complications, so for diagnostic purposes it is performed only when the test results are inconclusive, there is no option to perform non-invasive tests and there is a need to take samples for histopathological examination. An undoubted advantage of ERCP is also the patient's avoidance of surgical treatment (Wiercińska 2022).

Endoscopic ultrasonography (EUS, endosonography) is a method of diagnostic imaging in which an ultrasound scanner is used endoscopically to visualize the internal organs of the chest and abdominal cavity. It allows for a thorough assessment of the inside of the digestive tract, its walls, as well as adjacent organs. This method allows diagnostic and therapeutic procedures to be performed. The most common indications for the test are pancreatic diseases, gastrointestinal cancers and biliary stones. In addition, endoscopic ultrasonography allows for certain therapeutic procedures, such as drainage of pancreatic cysts and peripancreatic fluid reservoirs, drainage of the bile ducts and neurolysis of the celiac plexus. The quality of the imaging is directly proportional to the frequency used – a high frequency produces better quality images. However, the use of high frequency reduces the depth of penetration available in the test (Wiercińska 2022).

New cholangioscopy with image enhancement TXI and RDI

Texture and color imaging (TXI) and dichromatic red imaging (RDI) modes are among the new technologies used in endoscopy (Sato 2021, Miyamoto et al. 2021).

TXI aims to improve three white light imaging (WLI) factors – texture, brightness and color, allowing subtle differences in tissues to be distinguished. In this case, the image processing technique modifies the enhancement based on the Retinex theory with color enhancement. The basis of the above theory is the division of the image into two separate layers

– the base layer and the detail layer, which correspond to the features of human vision. The base layer represents the lighting component, while the detail layer corresponds to the local brightness and color contrast. This makes it possible to highlight subtle tissue differences while maintaining insight into the WLI, as well as improving color tones and making it easier to recognize subtle color differences (Sato 2021).

Preliminary studies have shown that TXI strikes a balance between improving the image characteristics that are important to the operator (selective brightness increase, greater color separation and texture enhancement) while minimizing large changes that can negatively affect familiarity (naturalness) (Sato 2021).

Red dichromatic imaging (dual-infrared imaging) is also a novel endoscopic technology that improves vision and enables easy and fast detection of exposed blood vessels. This technique uses three wavelengths of light – 540 nm, 600 nm and 630 nm, thanks to which significant differences in color are obtained between the vessels and the surrounding tissue. This allows the contrast of deep tissues to be emphasized (Miyamoto et al. 2021) .

It has been shown that image-enhanced cholangioscopy has been used in the diagnosis of bile duct cancers (Ishii et al. 2022).

Endoscopic Ultrasound with Flow Imaging (DFI-EUS)

The high incidence and mortality rate of diseases related to the pancreas and bile ducts leads to the development of newer and newer diagnostic methods. The latest discovery is endoscopic ultrasonography with flow imaging (DFI-EUS), which allows the detection of slow flow in microvessels, without the formation of motor artifacts and the administration of contrast agents (Wang et al. 2023).

Doppler ultrasound reveals both blood flow and motion artifacts – signals from the motion artifact overlap with low-velocity blood flow components. Conventional Doppler uses a one-dimensional wall filter to remove motion artifacts, which then leads to the loss of a "slow" component. Suppressing slow elements results in data loss, and consequently it is impossible to observe blood flow in smaller vessels. Endoscopic ultrasonography with flow imaging (DFI-EUS) avoids this type of event because, instead of suppressing the low-flow signals, it separates them from the underlying tissue movement artifacts, allowing them to be imaged (Wang et al. 2023).

The innovative endoscopic flow imaging ultrasound (DFI-EUS) technique both exceeds and exceeds the capabilities of traditional Doppler techniques, as it can visualize blood flow at lower speeds with high resolution. In this way, it expands the range of images that can be visualized, and also allows to image low microvascular flow, which is not possible to visualize by other methods (Wang et al. 2023).

One of the advantages is also the fact that DFI-EUS does not require additional material resources, as well as additional time that must be spent on testing, as in the case of CE-EUS. Nevertheless, appropriate instrumentation is necessary to perform the procedure – a convex endoscope (GF-UCT260; Olympus, Tokyo, Japan) with ultrasonic observation systems (ARIETTA 850; FUJIFILM Healthcare, Tokyo, Japan) (Wang et al. 2023).

The results of the research conducted on the new endoscopic ultrasound technique are extremely promising. DFI-EUS is significantly superior to e-FLOW EUS in differentiating parietal nodules from mucinous clots in IPMN, as well as in differentiating solid gallbladder lesions from gallbladder sediment. DFI-EUS is more sensitive than e-FLOW EUS in vascular detection and differential diagnosis of gallbladder lesions and IPMN. Vascular evaluation with DFI-EUS can be a useful and simple method to differentiate parietal nodules and mucinous clots in IPMN, solid gallbladder lesions and sediment, and malignant and benign gallbladder lesions (Wang et al. 2023, Ishii et al. 2022).

Novel low echo reduction function during endoscopic ultrasound observation of the gallbladder

Endoscopic ultrasonography (EUS), thanks to its high spatial resolution, is an indispensable element used in diagnostics, both in terms of the nature and invasiveness of gallbladder lesions. The bile ducts and gallbladder are hollow organs that originally do not have internal sources of echo, and thus are susceptible to multiple reflections and other artifacts (Toyonaga et al. 2023).

Recently, a new endoscopic ultrasound (EUS) processor has been introduced to the market, enabling an innovative low echo reduction function that reduces the formation of artifacts during ultrasound assessment of the gallbladder. It uses a technology called Low Echo Reduction (LER). LER suppresses low-echo areas while maintaining high-echo areas, thereby improving contrast without the white effect. In addition, the LER level can be easily changed both when the EUS screen is active and when it is paused (Toyonaga et al. 2023).

Tornus ES – spiral dilator for ultrasound-guided endoscopic drainage

In the last years of the decade, ultrasound-guided endoscopic biliary drainage (EUS-BD) – EUS-guided hepaticogastrostomy (EUS-HGS), EUS-guided choleincystodenostomy and EUS-guided hepaticojejunostomy (EUS-HJS) as a rescue therapy have gained popularity. The results of previous studies are promising and over time EUS-BD may become the primary means of bile drainage. The development of this field of medicine is closely related to the ineffectiveness of transpapillary drainage and the search for alternative treatment methods. This is associated with the development of newer and newer techniques of drainage under the control of EUS, including gallbladder drainage (EUS-GBD), pancreatic duct drainage (EUS-PD) and pancreatic pseudocyst drainage (EUS-PCD), as well as the creation of new endoscopic accessories that facilitate and accelerate the procedure (Ong et al. 2022).

The most technically difficult stage of drainage under EUS control is the process of expanding the puncture path, which makes it the main problem that arises during the procedure. This prompted a team of East Asian physicians to develop a novel spiral dilator as well as conduct clinical trials (Ong et al. 2022).

The Tornus ES spiral dilator is a newly developed accessory with a tapered screw-shaped tip, guiding 7 Fr from the maximum outer diameter and two lines up from the inner diameter, adapted to 0.025 inch and 0.018 inch guides. The tip of the dilator is moved by turning the closer handle of the dilator clockwise, which results in an extension of the puncture path. Unlike other traditional dilators, pushing movements along the axis of the cable are almost unnecessary, as the tip automatically moves due to the screw design. Once sufficiently moved, the dilator is retracted when the assistant turns it counterclockwise (Ong et al. 2022).

During clinical trials, the Tornus ES spiral dilator was used in people diagnosed with biliary obstruction caused by pancreatic cancer, bile duct cancer, gallbladder cancer and bile duct stones, as well as in patients with acute cholecystitis complicated by cancer. In all cases, the technical efficiency as well as the expansion efficiency with this accessory was 100%. In addition, the average duration of the procedure was 27 minutes and there were no adverse events related to the procedure, including peritonitis and bleeding, which gives high expectations for this method (Ong et al. 2022).

Hanarostent Z-EUS IT – metal superimposed stent on light enhanced by cautery (LAMS)

Modern treatment methods introduced recently include EUS-GBD made with the use of an innovative metal stent adjacent to the lumen, reinforced by cautery (LAMS). It is a 12 mm (diameter) x 30 mm (length) stent, fully covered and flush with a flange distance of 22 mm (Yamashita et al. 2023).

The procedure is carried out in an endoscopy laboratory with the possibility of fluoroscopy, which is necessary at one of the stages of the procedure, and the opening and arrangement of both collars, both proximal and distal is fully controlled by the endoscopist. The opening of the distal collar can be confirmed by endoscopic ultrasonography (EUS), while the opening of the proximal collar is visualized endoluminally (Yamashita et al. 2023).

The procedure can be successfully used, m.in e.g. in acute cholecystitis, due to the effective drainage of purulent content from the gallbladder to the duodenum. Another advantage is the time it takes to perform the procedure, which takes about 20 minutes (Yamashita et al. 2023).

The availability of cautery-assisted LAMS, installed by an endoscopist, allows precise placement of an EUS-guided stent for gallbladder drainage into the duodenum. It provides safer stent placement in tight spaces and reduces the need for an experienced assistant (Yamashita et al. 2023).

Disclosure:

Author's contribution:

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