INTRAOPERATIVE ULTRASOUND IN THE TREATMENT OF PANCREATIC DISEASES

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Intraoperative ultrasound (IOUS) allows confirming and verifying the preoperative diagnosis. In many cases it allows correct determination of the severity of the disease, safe surgery performance and shortening its duration. Proper assessment of anatomic structures during the surgery and evaluation of the operating field after the treatment termination, in combination with their ultrasound evaluation that permits more complete assessment of radical treatment.

The aim of the study was to define current indications for the use of intraoperative ultrasound in the treatment of pancreatic lesions, based on our own experience and the cited literature.

Material and methods. The Clinic, where the authors work, uses intraoperative ultrasound in everyday practice. In this paper we try to share our experience in this imaging technique. Studies were compared before the procedure both in the ultrasound and CT examination rooms with the images obtained intraoperatively. Intraoperative examination was performed by the surgeon who performed assessment before the procedure, what enabled verification of diagnoses. Presented material refers to 102 IOUS procedures performed during laparotomy due to pancreatic lesions.

Results and conclusions. IOUS is a reliable test for the evaluation of both inflammatory and acute lesions in the pancreas during the surgery of chronic, symptomatic pancreatitis. It correctly determines the extent of the planned surgery. In the case of pancreatic cancer it verifies local severity of the tumour lesions, assessing involving of the peripancreatic vessels, lymph nodes and the presence of local and distant metastases, including those in the liver. IOUS proved highly effective in the evaluation of endocrine and cystic pancreatic tumours. The study significantly improves the effectiveness of intraoperative BAC and aspiration or drainage of fluid reservoirs.

Key words: intraoperative ultrasonography, diagnostics, pancreatic diseases

Ultrasonography is the primary method in the field of diagnostic imaging of the abdomen. Currently, due to the extended range of technical ultrasound capabilities, this examination is able to replace a number of procedures in the field of classical X-ray diagnostics, such as computer tomography (CT), vascular examinations or even magnetic resonance imaging (MRI) (1- 4). It is the only recognized non-invasive (safe) imaging method.

IntraOperative UltraSonography (IOUS) first appeared in the sixties (5). Initially it was used for the diagnosis of abdominal cavity, especially in the assessment of cholelithiasis and biliary ducts. In the eighties, after the introduction of ultrasound presentation technique, B, Lane and Glazer described IOUS in “Lancet” as a useful method in the study of pathological lesions in the pancreas (6). Since then, there has been a significant progress in terms of technology, the emergence of the latest ultrasound machines of huge resolution, with modern multi-functional heads and software enabling accurate reading of the organ image. Ultrasound procedure became important not only in diagnosis; there has been also a significant development of treatment ultrasonography, including laparoscopic ultrasonography, LUS (4, 7, 8).

There is now a large selection of equipment used for intraoperative ultrasonography. Different types of probes with specific purposes, appropriate shape and characteristics of generated signal are used. Tests that better define

Unauthenticated
pancreas use high-frequency probes, mainly in the range of 7.5 to 10 MHz (1, 4). The shape and size adapted to possibility to assess the organ in two dimensions: longitudinal and transverse. Currently, the most commonly used probes are in the shape of a “T” or “I”, they are usually of convex type, less commonly sectoral or linear. The equipment must be easy to sterilize and easy to use.

In order to intraoperatively evaluate pancreas, it must be properly released from the surrounding structures, as only the direct application to the head to the organ allows proper imaging and capturing the details of construction as well as lesions (4, 9). In cases when it is not possible to reach pancreas only by a surgical procedure, it is possible to perform organ ultrasound through the left lobe of the liver or acoustic window formed by pressing the stomach wall (4). In order to better illustrate the head of the pancreas and the surrounding structures in these conditions, it seems useful to put the probe through the duodenum, even from the side, directing it toward the portal vein. When assessing the head of the pancreas, attention should be paid to such anatomical structures as pancreatic uncinate process, portal vein and portal-mesenteric confluence and superior mesenteric artery. With further examination we show elements of the hepatoduodenal ligament—the common bile duct and vascular structures, respectively: gall-bladder and, toward the left side of the organ—large arteries, splenic vessels and spleen cavity (1, 4, 9).

Pancreatic parenchymal echogenicity is assessed as being slightly greater in relation to the liver tissue. It depends on patient’s age, but mainly on the content of fibrous and fatty elements (3, 4). Increased pancreas echogenicity is characteristic for chronic pancreatitis, where the amount of fibrous elements and calcifications increases with the reduction of normal organ parenchyma (4, 10). Abundant retroperitoneal adipose tissue and its infiltration on pancreas can in some patients cause the difficulty imaging the edge of the organ. Useful under these conditions appears to be to defining the location of adjacent vascular structures, as well as running along and intersecting pancreas (4).

Intraoperative ultrasonography is more often used during procedures performed on pancreas. This is mainly in cases of tumour, cancer lesions, but currently also during surgeries of acute and chronic inflammation of the pancreas (2, 3). The main task is to visualize focal lesions, determine their nature and the border and to collect biotic material during the surgery. IOUS allows for differentiation of cystic, solid-cystic and solid lesions in pancreas and in its proximity (2, 11). An important element is the assessment of secondary lesions in the course of both inflammation of the pancreas and the result of pancreatic cancer expansion, with the possibility of involving lymph nodes and tumour metastases growth.

This article is an attempt to define current indications for the use of intraoperative ultrasound in the treatment of pancreatic lesions, based on our own experience and the cited literature.

MATERIAL AND METHODS

In the Second Department of General, Gastroenterological and Cancer Surgery, intraoperative ultrasound has been performed since 1996. Since then, about 500 procedures have been performed, mainly due to various liver and pancreas diseases. Since 2007, IOUS test has been performed using the new BK Medical Pro Focus system, the probe 5-12 MHz, with oblong “T” shape, adapted for intraoperative biopsy and ablation. Previously, linear probe and ultrasound Hitachi EUB 410 were used for this purpose. In 2007-2014, 220 procedures of intraoperative ultrasonography were performed, including 102 cases of laparotomy due to various pancreatic diseases. In imaging and preoperative studies, percutaneous ultrasound, including Doppler, was used, 185 patients underwent multislice CT and 31 – MRI or PET. In patients with confirmed primary disease of the pancreas, in most cases, the most common cause of IOUS were tumours suspected of neoplastic proliferation. 62 patients were enrolled to the procedure, 29 (of 46 performed) of which are lesions with confirmed or suspected cancer of malignant transformation (BACC). Others required intraoperative verification of pancreatic tumour. In 50 patients, IOUS was performed mainly due to chronic pancreatitis in order to verify the nature of larger lesions of the enlarged pancreatic duct and identification for deposits and cysts. Only
a small percentage of examinations were performed for intraoperative assessment of lesions in the course of acute pancreatitis, mainly to show purulent and fluid reservoirs. Before each procedure, intraoperative probe (BK Pro Focus) was sterilized in appropriate antiseptic fluids. Disposable covers, used also in laparoscopy, were utilized. During the test, the entire pancreas was evaluated from the head imaged through the duodenum and the direct application of the probe to the organ, after the incision of bursa and releasing all the adhesions, starting from the stomach curvature to the root of the transverse colon mesentery. Still the body was assessed, then the tail of the pancreas, reaching into the spleen cavity. We paid attention at the lobular parenchyma construction, dimensions, adjacent vessels, including the assessment of Doppler flow. Evaluation included pancreatic lesions, lesions of its surroundings, impressions or invasion of vascular infiltrations, and in the case of involving peri-pancreatic lymph nodes and whether there has been subsequent formation of metastases, mainly in the liver and also in other lymph nodes. During laparotomy in pancreatic inflammation – the extent and type of secondary degenerative lesions and reconstruction of the structure of the pancreas were assessed. In cases of unexplained nature of lesions in the pancreas, with the suspicion of malignant transformation, IOUS was performed during the procedure, and under its supervision – focal lesions BACC and collection of tissue for intraoperative imaging.

RESULTS

IOUS was performed in a group of 102 patients operated due to pancreatic diseases identified in previous imaging and laboratory tests. Of these patients, in 62 malignancy was suspected, both in cytology in fine-needle biopsy and in a variety of imaging studies, defining the nature of malignant tumour. In all, the level of tumour marker CA 19-9 was indicated, rarely titre of CA 125 or CEA marker were tested.

Pancreatic tumour lesions in the study group (62 people) were located mainly in the head of an organ – 44 cases (71%), 9 in the stem (14.5%) and 9 in the tail (14.5%). In 56 cases, solid tumour construction was confirmed, in 6 cases lithium-cystic, with the characteristics of cystic tumours of the pancreas. In these patients, BACC with aspiration was performed before the surgery. Content analysis (cytology, evaluation of the level of markers, the study on the content of mucus) in only two patients gave a positive result; the remaining analysis was not conclusive. During the surgery, in 5 cases, the tumour resection with a relevant portion of the pancreas was performed. In the last patient, malignant tumour infiltrating the neighbourhood together with liver metastases was confirmed. This case was assessed as inoperable. IOUS proved to be an effective method of intraoperative assessment in terms of determining the structure of cystic tumours, determining the border of the resection, and in the latter case, imaging small metastases in the liver.

In the case of 56 solid tumours with suspected presence of cancer qualified for the treatment, IOUS with assessment of the tumour size, location in relation to the portal-mesenteric confluence and other veins and arteries was performed during laparotomy. Echogenicity and tumour structure, the presence or absence of degenerative or breakdown lesion, the presence of enlarged regional and further lymph nodes was examined thoroughly. The width of the common bile duct and Wirsung’s duct were determined. An important element was to assess the presence of liver parenchyma with metastatic lesions.

In the study group, in 29 patients before the surgery, presence of cancer cells was confirmed or high probability of malignant transformation in performed percutaneous needle biopsy of the tumour was indicated. Revision in 53 operated was intraoperative with collecting biopsy material, usually tissue specimens, controlled by IOUs, or as a result of the histopathological material of the removed tumour evaluation. In this group, cancer was confirmed in 42 patients. The remaining 11 cases were negative for cancerous cells. In the IOUS examination in 7 patients in this group, high probability of tumour of a different nature than cancer was stated. In an ultrasound, minor character fibrosis, calcifications, or other mainly degenerative lesions were shown, which may correspond to the presence of the proinflammatory tumour, usually in the course of chronic pancreatitis imitating cancer metabolism. Table 1 shows the results of deter-
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Table 1. IOUS examination in patients undergoing surgeries due to lesions of the pancreas (2007-2014)

<table>
<thead>
<tr>
<th>IOUS in patients undergoing surgery due to pancreatic diseases</th>
<th>102</th>
</tr>
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<tbody>
<tr>
<td>Cystic tumours</td>
<td>6</td>
</tr>
<tr>
<td>Confirmation of pancreatic cancer</td>
<td>42</td>
</tr>
<tr>
<td>Suspicion of cancer without confirmation</td>
<td>4</td>
</tr>
<tr>
<td>Pancreatic diseases with nature other than cancer</td>
<td>50</td>
</tr>
</tbody>
</table>

Table 2. The severity of pancreatic cancer in 42 patients with confirmed pancreatic cancer who underwent IOUS

<table>
<thead>
<tr>
<th>The severity of pancreatic cancer</th>
<th>TNM</th>
<th>Number of patients</th>
</tr>
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<tbody>
<tr>
<td>I A-B T1-T2, N0, M0</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>II A-B T1-T3, N0-1, M0</td>
<td>13</td>
<td></td>
</tr>
<tr>
<td>III T4, N0-1, M0</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>IV T1-T4, N0-1, M1</td>
<td>15</td>
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DISCUSSION

Pancreatic tumours

While percutaneous ultrasound is the basic procedure, and with correct interpretation, further diagnostic algorithm, more advanced ultrasound techniques can identify important details of the study, comparable to other imaging techniques. Possibilities of ultrasound evaluation extension: Endoscopic ultrasonography (EUS), ultrasound BACC or EUS, colour Doppler and power Doppler, tests using contrast agents, 3D ultrasound and Doppler 3D, harmonic ultrasonography in the phase of encoded inversion, elastography and intraoperative and laparoscopic ultrasonography (4, 12-15). Intraoperative ultrasonography is a useful technique, helping to solve problems in pancreatic surgery during resection of the liver and in various therapeutic and diagnostic procedures during laparotomy (12, 16, 17). IOUS and LUS are currently most frequently used in the intraoperative assessment of the liver, gallbladder pathology evaluation of biliary tract construction (6-9). The main task is to determine the nature of focal lesions of the liver and the extent of resection of liver cancer in terms of criteria as well as the supervision of ablative procedures in the case of metastatic tumours. Most of the preoperatively diagnosed primary and secondary neoplastic lesions malicious in nature are not eligible for surgery. An important element of the examination is also determining activities of the lymphatic system, on different floors, both in the peritoneal and retroperitoneal cavity (7, 9).

Using IUOS changes previous surgical plans based on preoperative imaging tests, even in 38-49% of cases (5, 9, 12).

Pancreatic surgeries are still the toughest in abdominal surgery. IOUS and LUS can have a significant impact on decision making about the type of planned surgery, or even to withdraw from its performance. The procedures are used for differentiation of focal lesions of the pancreas, especially pancreatic ductal carcinomas and inflammation, endocrine, cystic, intraductal tumours (1, 4, 7, 15, 19). The most useful for the surgeon seems to be proper identification of pancreatic islets cell tumours,
rarely other endocrine tumours, including hormonally inactive tumours (1, 16, 18). Currently recommended method that helps in their identification is to extend the study by Doppler imaging (4, 14, 20). High hopes for the application of new laparoscopic heads are associated with surgery of pancreatic endocrine tumours, even when accurate preoperative diagnosis was performed (1, 4, 21). Laparoscopic ultrasonography allows for accurate determination of pancreatic cancer, and especially for imaging metastatic lesions both on the peritoneal surface and superficial lesions in the liver. Using laparoscopic ultrasonography, including BACC, improves the effectiveness of the evaluation study to the value of 88%, unless it is done under the supervision of an experienced physician (8). It allows collecting the material from both the tumour and sites with probable metastases, including the lymphatic system, the liver and other abdominal lesions.

In the last decade, preoperative diagnosis, mainly imaging, has been greatly improved, yet differentiating tumour-like pancreas lesions of ambiguous nature and lesions visualized only during laparotomy still remain problematic (15, 22, 23). Intraoperative ultrasound is the method of choice in such situations, where there are no other alternative diagnostic methods (17). High resolution used in intraoperative probes allows the correct visualization of almost entire pancreas. This is possible after the direct application of the probe to the organ (12, 22). Pancreatic cancer can often be surrounded by an outer layer without tumour cells. This may be associated with increased tumour submucosa and tissues corresponding to secondary, inflammatory processes coexisting with cancer and degenerative, necrotic lesions, in the course of the tumour enlargement (fig. 1) (23, 24). Such non-uniform echogenic areas are adequately visualized in IOUS and can be interpreted in a much more sensitive manner than palpation examination, which is burdened with a large percentage of diagnostic errors (12, 18, 22, 25). IOUS defines the criteria indicating the presence and location of the tumour mass, echostructure, homogeneity of the tumour, showing its borders and presence of non-pancreatic disease (lymph nodes, infiltration of adipose tissue, vascular walls of the gastrointestinal tract, further tumours) (4, 15, 18).

Imaging diagnosis of focal lesions in the pancreas is mainly focused on the confirmation or exclusion of cases likely to respond to adenocarcinoma. The most common form of cancer may be estimated as 70-85% of pancreatic nodular lesions. The main aim of ultrasound is the imaging of the tumour, distinguishing it from other commonly-inflammatory or post-inflammatory solid lesions and performing qualification aimed to establish a specific way of treatment, which is mainly dependent on the severity of cancer (1, 3, 7, 13). IOUS has a natural advantage over conventional examination, which is conditioned by the directly putting the head to the organ. This allows cutting the gastro-colonic ligament and duodenal mobilization (Kocher’s manoeuvre) (12). At this stage IOUS presents four diagnostic degrees: imaging focal lesion, determining the ratio of the changes in the main pancreatic duct, assessing operability with regard to veins and arteries and evaluation of the liver and lymphatic system (1, 12). In the event of lesions in the uncinate process, the possibility of vein and superior mesenteric artery infiltration should be checked. If lesions involve mainly the head of the pancreas, one has to carefully evaluate the superior mesenteric vein, portal-mesenteric confluence, portal vein, gastro-duodenal vein and hepatic arteries. If the focus is near the isthmus, the course of the superior mesenteric vein should be examined as well as portal-mesenteric confluence, portal vein, superior mesenteric artery, common hepatic artery and celiac trunk. When focal lesion is located in the distal part of the body and tail of the pancreas, IOUS is to define the relation-
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ship of the tumour to splenic vessels, over their entire length (fig. 2) (12, 18). In addition, it allows assessing whether the tumours infiltrate splenic hilus, capsule, the structure of the left kidney and the retroperitoneal space, including vessels in the area.

Intraoperative verification of the tumour helps to identify the most optimal place to perform BACC, both during laparotomy and laparoscopy (1, 26). The combination of IOUS and fine needle or core needle biopsy allows you to achieve high diagnostic accuracy, where both sensitivity and specificity reach 90-100% (23, 24, 25). An important side of intraoperative ultrasound is assessment of peripancreatic vascular infiltration, portal vein flow, superior mesenteric artery and celiac trunk. In one of the first comprehensive studies, Machi et al. (17) demonstrated a significant advantage of sensitivity, specificity and accuracy of IOUS in the diagnosis of neoplastic infiltration in the portal vein flow, compared with preoperative studies – percutaneous ultrasound, angiography and computer tomography. For example, the accuracy of IOUS was determined as 89.7% compared to 64.1%, of the average value of other imaging tests. Modern multidetector computer tomography (MDCT) allows for a better assessment of tumour severity with the ability to assess vascular infiltration. The sensitivity of the method is evaluated in the range of 90-98.4%, however, determination of the possibility of tumour resection based on the MDCT shows lower statistical sensitivity, within a range of 71.4-90% (1, 12, 27). Accurate determination of vascular invasion in the diagnosis of pancreatic cancer based on IOU is currently estimated on average in the range of 92-93% (sensitivity), with a similar specificity of the sample, an average of 95% (1, 4, 9, 12).

Intraoperative examination also allows reliable imaging of enlarged peripancreatic lymph nodes. They are difficult to distinguish especially in the presence of existing inflammatory reaction, extensive infiltration of surrounding structures or abundant adipose tissue (12, 25). Due to the possibility of direct application of the probe to the surface of the organ, IOUS is also the most reliable method assessing the presence of metastases in the liver, including even lesions of the size of 5 mm (22, 26). In the studies high sensitivity of the method was determined. Its average value is around 94%, compared to 86.7% using magnetic resonance imaging (MRI) (1, 12). During the study, parenchyma should be carefully evaluated by putting the probe on both the front surface of the liver, directing it upward toward the cupula, then bottom surface; after releasing often existing adhesions, the back surface of the organ should also be assessed (12). In patients with resectable tumours in the pancreas, imaging problematic or not visible in preoperative examinations liver lesions requires emergency biopsy performed under the control of IOUS (4, 12). BACC is also important in unresectable cases where making diagnosis becomes relevant in the determination of further therapeutic intervention, mainly palliative (chemotherapy). Confirmation of the intraoperative biopsy of liver metastases usually completely changes the treatment plans. In our material IOUS was performed in 56 cases of solid pancreatic tumours qualified for the treatment of suspected cancer. IOUS assessed mainly the tumour size, placement in relation to the portal-mesenteric confluence and other veins and arteries. In addition, tumour structure, the presence or absence of degenerative or breakdown lesion, the presence of enlarged regional and further lymph nodes was assessed.

Fig. 2. IOUS with power Dopler. Pancreas body tumour, infiltration of the splenic vein

Cystic tumours are relatively rare in pancreas. It is presently believed that 2% to 4% of cystic lesions of the pancreas can be malignant cystic tumours (28, 29). A characteristic feature in imaging examinations is the wall thickening, often segmental, and the formulation of nodules in the wall or inside and calci-
Acinar structures in the cyst and internal partitions can also be noticed. The most commonly used methods in addition to ultrasound and CT include aspiration of the contents under the ultrasound, EUS, aspirations under the control of EUS (EUS-FNA) and IOUS. Numerous small cysts sometimes with internal calcification, forming polycyclic systems are characteristic for serous adenocarcinomas. The image of the cystic enlargement of the pancreatic duct suggests intraductal papillal-mucinous pancreatic cancer (IPMN) and the presence of cystic lesions of non-uniformly thickened wall – mucinous cystic tumour (4, 19, 28, 29).

IOUS test is essential in the surgical treatment of cystic tumours. It is important to pinpoint the exact location of lesions. Be aware that there may be multiple tumours not detected in preoperative examination. Pathology of cystic tumours also varies. This can be benign or malignant forms, infiltrating surrounding structures and metastases, including lymph nodes and liver (4, 28, 29). The basis for qualification for surgery seem to be primarily diagnostic imaging, clinical examination, to a lesser extent, the data obtained from the aspiration of fluid from the cyst. In serous tumours, small asymptomatic lesions with diameter of 2-3 cm are suitable for observation. In other cases, tumour resection should be considered, even with the use of minimally invasive techniques. While determining mucinous pancreatic tumour it should be remembered that these are the most common forms of malignant or high-grade dysplasia, eligible for surgical treatment. Full assessment of the tumour nature is possible only after excision and histopathological examination of the lesions (30, 31). The above tactic was adopted in our clinic.

Pictured change of the type of IPMN may also have a different character. Peripheral forms are usually benign, while those concerning the main pancreatic duct are more often malignant, invasive forms (4, 19). The tumour has the appearance of papilloma or polyp which grows out of the pancreatic duct epithelium. The cause of lesions is usually high-grade dysplasia in border form or even change in the type of cancer (as a locally reduced form or invasion). Therefore, there are specific indications for surgical resection of the tumour in the central form, even in cases of total pancreatectomy with wide involvement of the main duct. When making a decision about surgical treatment in the peripheral location of the tumour you should take into consideration patient’s condition and therefore the existing risks and benefits of the surgery with certain ailments, severity of the local tumour (> 3 cm) and patient’s burden. Intraoperative ultrasound in many cases helps to make a final decision as to the scope of the surgery, the resection border and the differentiation of cysts and cystic tumours of the pancreas, although previous studies (not only imaging), but when there are still some diagnostic confusions (4, 19, 28, 30, 31).

Contemporary challenge for imaging diagnostics are neuroendocrine pancreatic tumours, whose most common form is pancreatic islet cell tumour. These are usually single lesions with the size of 1 cm, in ultrasound or partially with a much reduced echogenicity, homogeneous construction, well separated (3, 4, 12). Some of neuroendocrine tumours show no hormonal activity. The imaging studies are as well-differentiated lesions, located mainly in the head and the body of the pancreas, rarely in the tail (fig. 4). Most often these are differentiated neuroendocrine carcinomas, growing and expanding, symptoms are observed relatively late, sometimes when there are already metastatic. In some cases, hormonally active islet cell tumours may be isoechogenic, what means that they are difficult to distinguish from the rest of the pancreatic parenchyma. This makes initial diagnosis imaging tests harder, particularly in percutaneous ultrasound. The use of a contrast agent

Fig. 3. IOUS with power Doppler. Serous adenocarcinomas cystoma, numerous small cysts forming polycyclic systems
(CEUS examination) and ultrasound heads with high-resolution, harmonic imaging has a significant impact on the proper imaging of the internal vascularity of the tumour and preventing diagnostic mistakes. The increased flow is observed in pancreatic islet cell tumours and partially in neuroendocrine tumours (12, 32).

IOUS is at a high resolution analysis of the examined image a very effective diagnostic method for small, poorly differentiated endocrine tumours, with often not visible location (1, 3, 4, 12, 16, 26). In cases where the preoperative imaging methods fail to determine the position of the insulin-secreting islet cell tumour, the method may be used selectively, determining the concentration of insulin in the portal vein and its branches, after selective catheterization of venous vessel or determining the level of insulin after selective administration of calcium gluconate to peripancreatic arteries on their different altitude (16). In such patients, the best way to proceed seems to be a combination of reliable diagnostic methods of preoperative diagnosis, with surgical technique based on the possibility of a correct implementation of the IOUS (3, 16, 18, 20). The presence of multiple foci of neuroendocrine tumours and a rare non-pancreatic location (16, 20, 26) should also be kept in mind. IOUS is a more accurate diagnostic procedure compared to CT or MRI and even to the often recommended contrast-enhanced ultrasonography (CEUS). The sensitivity and specificity of the test was determined in the range of 90-96% and sometimes even close to 100% (1, 9, 12, 16). The procedure may be more accurate when using intraoperative Doppler (20).

In all doubtful cases, during the surgery, pancreas should be released from the surrounding structures, Kocher manoeuvre (mobilization of the duodenum) is also recommended (12, 18). Less frequently diagnosed neuroendocrine tumours include glucagonoma, gastrinoma, VIPoma, somastatinoma, carcinoid (4, 9, 16, 19). These tumours are hypo or isoechogetic in the ultrasound image, and like islet cell tumours are usually separated from the pancreatic parenchyma. More often, however, they show malignant lesions, including the possibility of formation of metastases.

The past several years have witnessed a significant progress in diagnostic imaging of the abdomen. In the ultrasound technology it is the appearance of high resolution cameras with modern multi-functional heads and software able to read the image in three or even four dimensions. This is technique, which using ultrasound contrasts penetrates into the structure of the organ, clearly indicating the place and nature of the focal length and diffused pathology. High hopes are also associated with the implementation of CE-IOUS technology (intraoperative ultrasound enhanced with contrast), not only in liver surgery, but also in other organs, including pancreas (12, 16).

Acute and chronic pancreatitis

Ultrasonography is one of the basic diagnostic procedures in cases of both acute and chronic pancreatitis. Surgical treatment for acute pancreatitis due to extensive infected necrosis, abscesses and pancreas abscesses, peripancreatic tissue, retroperitoneal space and concomitant intraperitoneal lesions, require the use of proper surgical technique. Preoperative imaging studies (ultrasound, CT) determine only generally the extent of lesion formation, which, due to extensive tissue damage, the exact location and nature, can only be assessed after, often complicated, laparotomy or opening of the retroperitoneal space. In such conditions, IOUS allows for proper access to the changed area, determines the surgical planes, places the outbreak or outbreaks larg-
est disintegration lesions of necrosis that should be reached, removed and drained (fig. 5) (4, 11, 14, 17). It also allows avoiding damage to important life structures, like main vascular branches, infiltrated parts of the gastrointestinal tract, the structure of the bile duct and the main pancreatic duct.

IOUS allows for accurate imaging of fluid reservoirs, distinguishing acute phase reservoirs, pseudocysts and inflammatory fluid in the abdomen, often limited by inflammatory or post-operative adhesions. Good interpretation influences the choice of appropriate treatment, choice of the type of drainage, to avoid many postoperative complications. Intraoperative Doppler allows for the differentiation of pseudocysts and pseudoaneurysms of the pancreas, which can be a complication of inflammation (4, 14). It also allows safe performance of the anastomosis procedure with Jurasz's method, in the avascular area (fig. 6).

The combination of preoperative imaging studies and IOUS seems to be the most reliable strategy to improve the accuracy of the differential diagnosis of focal lesions of the pancreas, and mainly to distinguish tumour malignancy from benign tumours (15). Changed head of the pancreas in chronic inflammation is accompanied with the characteristics of degenerative, fibrotic, calcified pulp, deposits in the duct (fig. 7). With appropriate setting of the probe we can determine curving, extended course of the pancreatic duct within the body, the presence of numerous calcifications inside duct and in the parenchyma of the pancreas (4, 10, 26). During the draining procedures, it allows to determine the location where the incision is made on the enlarged duct. It also helps in finding the stones causing obstruction, and their removal (3, 10). In our material, we use IOUS in virtually all treatments for chronic pancreas, this study allows for the proper conduct of the Puestow procedure and some deviations or additional procedures resulting from the presence of other inflammatory lesions, mainly pseudocysts (fig. 8).

Intraoperative ultrasonography determines differences in the construction of cystic, solid-cystic and solid lesions in pancreas and in its proximity (2, 11, 31). In the case of pseudocysts, it allows to locate their exact location in relation to the surrounding organs, which fa-
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cilitates decision about selecting the proper drainage (fig. 9). Another important task of IOUS is the differentiation of the liquid character in the reservoir due to their different echogenicity in the presence of inflammatory fluid, pus or haematoma. Earlier determination of the type of the content enables defining the operational strategy (3, 4).

CONCLUSIONS

Extending the treatment time by a few minutes devoted to the evaluation of ultrasound is apparent, in fact we shorten the total time of the surgery – a thorough assessment without extensive tissue preparation and interpretation of the test result does not depend on other professionals. IOUS should be widely used during the surgery of the pancreas, not only in pancreatic cancer staging or the presence of local and distant metastases, but also in differentiation of other solid, cystic changes, necrotic lesions, fluid reservoirs. This helps in choosing a particular course of action when confirming the presence of lesions of the organ and surrounding tissues.

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