Pancreatic cancer was the second cause of death due to malignant gastrointestinal neoplasms in women – and third one in men – in Poland in 2009 (1). Based on the same source, the standardised mortality rate for this complaint in our country stood at 5.15 per 100,000 per year in women and at 8.48 per 100,000 per year in men (1). Correct diagnosis and assessment of advancement stage in patients with pancreatic cancer are the basic prognostic factors enabling making the decision on the type of surgical treatment and the selection of combination therapy, as well as enabling the comparison of therapeutic results between the centres. The abdominal multidetector computed tomography (MDCT) with intravenous contrast agent administration should be a diagnostic imaging standard qualifying the patient with pancreatic cancer for proper treatment (2, 3). The value of computed tomography and magnetic resonance imaging (MRI) in terms of assessing the advancement stage of pancreatic cancer is comparable, while such examinations as positron emission tomography (PET) and endoscopic ultrasound (EUS) are used as auxiliary examinations in cases causing diagnostic problems (2, 4). However, in view of the wide availability, non-invasiveness, low cost and relatively high diagnostic accuracy, percutaneous ultrasound is routinely used, treated as a screening or auxiliary examination (visualisation of liver metastases) (5). The limitations associated with abdominal ultrasound examination, stemming from insufficient experience of the technician, low quality of the ultrasound apparatus or incorrect patient preparation, affect the divergent opinions on the efficacy of pancreatic cancer detection.

Based on the material from patients at our centre specialised in the surgical treatment of this neoplasm, in the present study, it was attempted to assess the value of routine ultrasound examination in preoperative diagnosis of pancreatic cancer, determination of its ad-
vancement stage and possibilities of prognosticating the type of surgical procedure.

MATERIAL AND METHODS

The study was conducted on a group of subsequent 409 patients undergoing surgery at 1st Department of General Surgery, Medical College Jagiellonian University in Cracow in the years 2000-2010. Patients in whom endocrine neoplasms had been diagnosed based on the postoperative histopathological examination were excluded, due to the different morphological picture of those lesions. Each of the patients was recorded in the Magic2 database maintained by the local Department, and they had granted their consent to the suggested diagnostics and treatment.

Abdominal ultrasound examinations with the use of Logiq 7 and/or Hitachi EUB 6000 units were performed in all patients – in some of them more than once. The ultrasound examination was performed according to the established study protocol, including the assessment of local, regional and systemic advancement of pancreatic cancer as per the 2002 UICC/AJCC TNM classification (6).

In patients qualified for surgical treatment due to pancreatic cancer, there was calculated the diagnostic accuracy of preoperative ultrasound examination in neoplasm diagnosis and in the local neoplasm advancement assessment T1-T4 as per the 2002 UICC/AJCC classification (6).

In the studied patients, the intraoperative finding of major artery infiltration, and in most of the cases also major abdominal vein infiltration, caused the resection procedure to be abandoned.

The following results of reference tests were adopted for the verification of diagnostic accuracy of percutaneous ultrasound examination: intraoperative surgical assessment, histopathology result for the surgical specimen, and in the case of non-resectional lesions – technician’s opinion and histopathology result for tissue samples. The confirmation of a presence of metastases in lymph nodes was done in patients in whom resections had been performed and in some of the patients who had undergone non-resectional procedures only, but lymph nodes had been collected intraoperatively for histopathological verification.

The diagnostic accuracy of abdominal ultrasound examination in the collected patient material for each of the evaluated aspects was calculated with the use of STATISTICA 9.0 (StatSoft) software. Student’s t-test was used in the statistical analysis of accuracy of preoperative ultrasound examination in the assessment of resectional potential of pancreatic cancer depending on the performed surgical procedure, with p < 0.05 adopted as statistically significant.

RESULTS

The mean age of 409 patients participating in the study was 60.7. Females constituted 47.9% (196 individuals), while males – 52.1% (213 individuals).

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The local pancreatic cancer advancement as per TNM was assessed, with verification based on the reference tests. It was found that the T1 advancement stage was present in 6.6% of patients, while T2 – in 15.2%. However, the majority of patients had a more locally advanced neoplasm: T3 – 35.4% and T4 – 42.8% of individuals (tab. 1).

52.8% of studied patients had undergone resection which in 33.5% of cases had been deemed radical and in 19.3% – non-radical. In the remaining patients (47.2%) a non-resectional lesion was found intraoperatively and the procedure was limited to palliative patency restoration or exploratory laparotomy (tab. 2).
Table 1. Local advancement of pancreatic cancer as per TNM in the studied patients, based on reference tests

<table>
<thead>
<tr>
<th>Local advancement of pancreatic cancer (T)</th>
<th>Number of individuals n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1</td>
<td>27 (6.6)</td>
</tr>
<tr>
<td>T2</td>
<td>62 (15.2)</td>
</tr>
<tr>
<td>T3</td>
<td>145 (35.4)</td>
</tr>
<tr>
<td>T4</td>
<td>175 (42.8)</td>
</tr>
<tr>
<td>Total</td>
<td>409 (100)</td>
</tr>
</tbody>
</table>

The calculated diagnostic accuracy of abdominal ultrasound examination in the pancreatic cancer diagnosis in all 409 patients stood at 91.1%. The accuracy of detecting the individual local advancement stages as per TNM with the use of abdominal ultrasound examination was assessed at 92.3% for T1, 91.3% for T2, 89.4% for T3, 92.1% for T4, and at 91.3% for T1-T4 in total (tab. 3).

In addition, the present study evaluated the diagnostic accuracy of abdominal preoperative ultrasound examination in the diagnosis of metastases to lymph nodes and infiltration of major retroperitoneal blood vessels (tab. 4).

The diagnostic accuracy of ultrasound examination in the diagnosis of pancreatic cancer metastases to lymph nodes in 268 patients stood at 80.7%. The diagnostic accuracy of ultrasound examination with an additional option of colour Doppler and power Doppler in the diagnosis of blood vessel infiltration was assessed at 86.0%.

Table 2. Surgery type in the studied patients

<table>
<thead>
<tr>
<th>Procedure type</th>
<th>Number of individuals n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radical resection</td>
<td>137 (33.5)</td>
</tr>
<tr>
<td>Non-radical resection</td>
<td>79 (19.3)</td>
</tr>
<tr>
<td>Non-resectional procedure</td>
<td>193 (47.2)</td>
</tr>
<tr>
<td>Total</td>
<td>409 (100)</td>
</tr>
</tbody>
</table>

Table 3. Diagnostic accuracy of abdominal ultrasound examination in the assessment of local advancement of pancreatic cancer as per UICC/AJCC 2002 (n = 409)

<table>
<thead>
<tr>
<th>Local advancement of pancreatic cancer (T)</th>
<th>Diagnostic accuracy of ultrasound examination (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1</td>
<td>92.3</td>
</tr>
<tr>
<td>T2</td>
<td>91.3</td>
</tr>
<tr>
<td>T3</td>
<td>89.4</td>
</tr>
<tr>
<td>T4</td>
<td>92.1</td>
</tr>
<tr>
<td>T1-T4</td>
<td>91.3</td>
</tr>
</tbody>
</table>

In the studied patients, there was also evaluated the possibility of prognosticating, with the use of preoperative abdominal ultrasound examination, of the type of performed surgical treatment (tab. 5).

The accuracy of ultrasound examination in the preoperative prognosticating of surgical procedure type in the studied patients stood at 91.4%. For resections, the diagnostic accu-
Diagnosis and advancement assessment of abdominal ultrasound examination was assessed in this aspect at 93.7%, while for non-resectional procedures – at 89%. There was no statistically significant difference found in the evaluation of resection potential of pancreatic cancer with the use of routine preoperative ultrasound examination depending on the type of performed surgical procedure (p > 0.05).

**DISCUSSION**

The aim of the present study was the determination of value of abdominal ultrasound examination in the diagnosis, advancement assessment and pancreatic cancer resection.

![Fig. 3. Head of pancreas cancer, T3 as per TNM, infiltrating the superior mesenteric vein and hepatic portal vein](image-url)

![Fig. 4. Tail of pancreas cancer, T4 as per TNM, infiltrating the celiac artery and abdominal aorta](image-url)

![Fig. 5. Body of pancreas cancer, T4 as per TNM, infiltrating the celiac artery and abdominal aorta](image-url)

**Table 4. Diagnostic accuracy of preoperative abdominal ultrasound examination in diagnosing the metastases to lymph nodes and infiltration of blood vessels in the studied group**

<table>
<thead>
<tr>
<th>Number of individuals n (%)</th>
<th>Diagnostic accuracy of ultrasound examination USG (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>268 (65.5) Przerzuty do węzłów chłonnych / metastases to lymph nodes</td>
<td>80.7</td>
</tr>
<tr>
<td>409 (100) Naciekanie naczyń krwionośnych / infiltration of blood vessels</td>
<td>86</td>
</tr>
</tbody>
</table>

**Table 5. Diagnostic accuracy of preoperative abdominal ultrasound examination in prognosticating the surgery type in the studied patients**

<table>
<thead>
<tr>
<th>Surgery type</th>
<th>Number of individuals n (%)</th>
<th>Diagnostic accuracy of ultrasound examination (%)</th>
<th>p*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resection</td>
<td>216 (52.8)</td>
<td>93.7</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>Non-resectional procedure</td>
<td>193 (47.2)</td>
<td>89</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>409 (100)</td>
<td>91.4</td>
<td></td>
</tr>
</tbody>
</table>

* statistical significance
prognosticating. The obtained results indicate an important role of the abovementioned imaging method in making the decision on therapeutic approach in the discussed neoplasm. However, the diagnostic accuracy of computed tomography and magnetic resonance imaging remains higher than that of ultrasound examination. In the majority of European and Asian countries, transabdominal ultrasound examination is the first examination performed in patients with pancreatic tumours, since it is cheap, widely available and easy to perform (2). The diagnostic accuracy of ultrasound examination in the detection of pancreatic cancer in the studied patients stood at 91.1% – a figure similar to those reported by other authors, e.g. Bipat and colleagues (5), Martinez-Noguerra and colleagues (7) and Sofuni and colleagues (8). According to the above reports, the efficacy of abdominal ultrasound examination in detecting the discussed neoplasm was assessed at 87-90%. Scialpi M. And colleagues (9), Kulig and colleagues (10) and Zajac and colleagues (11) have indicated higher diagnostic accuracy of ultrasound imaging in pancreatic cancer diagnosing with the application of optional colour Doppler, power Doppler and endoscopy, of 91-95%. The presented results of detecting pancreatic cancer with the use of ultrasound examination differ only slightly from those for other imaging methods, such as magnetic resonance imaging or computed tomography, including the type of the above examination with the use of an angio-CT contrast agent, currently deemed as being characterised by the highest diagnostic accuracy of 94-100% (5, 10, 12-14).

The present study evaluated the diagnostic accuracy of percutaneous ultrasound examination in diagnosing the individual local advancement stages of pancreatic cancer as per the TNM classification, which stood at 92.3% for T1, 91.3% for T2, 89.4% for T3, 92.1% for T4, and 91.3% for T1-T4 in total. According to the published reports, the efficiency of abdominal ultrasound examination in the discussed aspect ranges between 75% and 95% (10, 15-16). Phoa and colleagues (17) and Bronstein and colleagues (18) have evaluated the accuracy of T assessment as per the pancreatic cancer TNM, with the use of computed tomography at 100%, if the lesion was larger than 2 cm (> T1), and at 70% – if it did not exceed 2 cm (< T1). Based on the more recent reports, the refining of computed tomography technique with the administration of an intravenous contrast agent enables the diagnosis with this method of local advancement of pancreatic cancer with efficacy markedly higher than 90%, irrespective of the stage (5, 10, 19, 20). Borbath and colleagues (21) and Sheridan and colleagues (22) have evaluated the efficacy of diagnosing local advancement of pancreatic cancer with the use of magnetic resonance imaging at 88-91%. The above results indicate that a correctly performed ultrasound examination enables a reliable assessment of local advancement of pancreatic cancer, one that is comparable to CT or abdominal MRI.

In patients participating in the study, there was evaluated the diagnostic accuracy of preoperative abdominal ultrasound examination in the diagnosis of metastases to lymph nodes and infiltration of major retroperitoneal blood vessels. The diagnostic accuracy in the diagnosis by routine ultrasound examination of metastases to lymph nodes was assessed in the studied group of patients at 80.7%. Gorlick and colleagues (16) have evaluated the efficacy in a routine ultrasound examination at 77%, while Sofuni and colleagues (8) and Bunk and colleagues (23), with the use of Doppler option, have found that it reaches 80-82.5%. Chen and colleagues (24), in their study, have questioned the diagnostic accuracy of routine ultrasound examination in the diagnosis of metastases to lymph nodes in patients with pancreatic cancer, assessing its efficacy at no more than 33%. According to Kulig and colleagues (10) and Soriano and colleagues (25), the diagnostic accuracy in this aspect with the use of CT and MRI stands at 75-91.3%. The presented results of detecting metastases to lymph nodes in patients with pancreatic cancer with the use of ultrasound examination, with the exception of the study by Chen and colleagues (24), are similar as compared with other imaging methods analysed in the Discussion section, such as computed tomography or magnetic resonance imaging.

The efficacy of detection by percutaneous ultrasound examination with the use of colour Doppler and power Doppler options of major blood vessel infiltration by pancreatic cancer in patients analysed in the present study stood at 86.0%. American reports (26) evaluate the
diagnostic accuracy of routine abdominal ultrasound examination in the diagnosis of blood vessel involvement by the analysed neoplasm at approx. 60%, while according to Kulig and colleagues (10), Bunk and colleagues (23) and Dabizzi and colleagues (27), when the Doppler option is used, the accuracy goes up significantly and reaches 80-96%. Kulig and colleagues (10), Karmazanovsky and colleagues (19) and Ellsmere and colleagues (20) have evaluated the efficacy of abdominal CT scan in diagnosing the vascular infiltration by pancreatic cancer at above 90%, and the combination of conventional computed tomography with traditional angiography currently provides a diagnostic accuracy in this aspect of 95-100% (28). Lopez-Hanninen and colleagues (13) have assessed the diagnostic accuracy of MRI in blood vessel infiltration by the discussed neoplasm at 94%. According to Gorelick and colleagues (16) and Chen and colleagues (24), the efficacy of detecting vascular infiltration with the use of CT and MRI does not exceed 80% considering patients with the discussed neoplasm. Thus, it appears that one of the main factors from the point of view of a surgeon in surgical treatment of patients with pancreatic cancer, one deciding on the resectional potential of the lesion, may be evaluated with the use of ultrasound examination with Doppler options with a slightly lower efficacy than that of computed tomography with the use of a contrast agent and abdominal magnetic resonance imaging. Still, the gold standard in the determination of advancement and resectional potential of pancreatic tumours remains computed tomography.

In patients analysed in the present study, there was also evaluated the possibility of prognosticating the type of surgical treatment in patients with pancreatic cancer. Spiral computed tomography or magnetic resonance imaging is a valuable diagnostic method in patients with pancreatic cancer. Still, the gold standard method of prognosticating the type of surgical treatment in patients with pancreatic cancer has been assessed by Gorelick and colleagues (16) at 82.5%, and the use of Doppler technique increased the above rate to markedly above 90% (2, 10, 28). According to Kulig and colleagues (10), Phoa and colleagues (17), Sheridan and colleagues (22) and Soriano and colleagues (25), the percentage of correct diagnosis in this aspect for computed tomography and abdominal magnetic resonance imaging stood at 83-96%, while Bipat and colleagues (5) have deemed CT the best imaging method in evaluating the resectional potential of pancreatic cancer. Still, the gold standard in the evaluation of resectional potential of pancreatic tumours remains the intraoperative assessment of tumour advancement by the surgeon, particularly as regards the major vessel infiltration. The finding of major artery infiltration (the celiac artery, superior mesenteric artery, common hepatic artery) in preoperative examinations is considered a contraindication against surgery, while vein infiltration does not rule out resection (29). However, in the majority of patients analysed in the present study, pancreaticoduodenectomy had not been performed in the case of identified major vein infiltration. Based on the obtained results, it might be concluded that the preoperative ultrasound examination is a reliable method of prognosticating the type of performed surgical procedure in patients with pancreatic cancer, one characterised by a slightly lower diagnostic accuracy than that of computed tomography or magnetic resonance imaging.

Own results and published reports indicate that routine abdominal ultrasound examination is a valuable diagnostic method in patients with pancreatic cancer. Spiral computed tomography of the abdomen with contrast agent administration should be the main imaging examination qualifying the patient with pancreatic cancer for proper treatment. Recently, positron emission tomography (PET) has been becoming more widely available, and in combination with angio-CT it enables a more reliable evaluation of the pancreatic tumour nature. If the contrast agent cannot be administered, it is recommended to perform a magnetic resonance imaging examination, including magnetic resonance cholangiopancreatography (MRCP), as a non-invasive imaging
method for the pancreatic duct. In the overall analysis of the present study subject, abdominal ultrasound examination has a slightly lower diagnostic accuracy as compared with computed tomography or magnetic resonance imaging, but it is more easily available and is non-invasive for the patient. Ultrasound examination should be deemed the first-line imaging approach in diagnosing and surgery prognosticating in patients with pancreatic cancer, while other diagnostic methods should be applied only after performing the ultrasound examination. The second-line examinations remain to be computed tomography and magnetic resonance imaging. The high diagnostic accuracy of MDCT in solid tumours stems from isotropic resolution (same resolution in all dimensions), collimation enabling the obtaining of layers of < 1 mm in width, and multidetector imaging (2). Meanwhile, magnetic resonance imaging, particularly in combination with magnetic resonance cholangiopancreatography (MRCP), remains the gold standard in the diagnostics of cystic tumours of the pancreas, owing to the possibility of visualising the lesions in the pancreatic parenchyma and ducts, septa and lesions inside the cyst.

The third-line examinations, performed in certain patients with pancreatic tumours, remain to be PET (particularly in the case of neuroendocrine tumours and diagnosis of distant metastases of small size), EUS (possible detection of tumours of <10 mm in size, adjacent structure infiltration and enlarged lymph nodes) and intraoperative ultrasound examination (particularly useful in the diagnosis of multifocal neuroendocrine tumours and small-size metastases to the liver).

REFERENCES


