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Evaluation and treatment decision of pancreatic tumors by use of MRI with MRCP imaging

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Summary

Background:

Pancreatic cancer is one of the most malignant tumors. Symptoms are usually nonspecific and insidious such that the cancer is advanced by the time of diagnosis.

The aim of our work was to investigate the use of MRI and MRCP in diagnosis of the patients suspected of pancreatic carcinoma and to determine the role of these methods in the evaluation of resectability of pancreatic cancer in comparison to surgical findings.

Material/Methods:

Forty-nine patients (33 men and 16 women) aged 44–82 had undergone to MRI and MRCP imagination of the upper abdomen on 1.5 T system with use of a standard flexible surface coil. The results of those radiological diagnostic tests were compare to the surgical findings and histopathological examination. The capacity of MR and MRCP to detect pathological mass, assess disease process nature and accuracy of assessment of the resectability of the malignant lesion were evaluated. In the statistical analysis test X^2 and Fisher's precise test were performed.

Results:

A statistical analysis determined 88% sensitivity, 95% specificity and 94% exactness of MRI and MRCP in the evaluation of nature of tumors within the pancreas and 100% sensitivity, 91% specificity and 95% accuracy in determining the resectability of the lesion. The positive predictive value came to 83%, while the negative predictive value to 100%. The Kappa compatibility index in comparison with a surgical findings came to 0.85714.

Conclusions:

MR and MRCP appears an important stage in diagnosis and in assessment of pancreatic tumors. By the estimation of tumor resectability it aids clinical management.

Key words:

pancreatic carcinoma • diagnosis • MRI • MRCP • resectability

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Background

Pancreatic carcinoma represents the second most common cause of death from malignant tumors of the gastrointestinal tract [1]. It is marked by unfavorable prognosis due to difficulties in early diagnostics, its aggressive character and low efficiency of medical proceedings [2,3]. An early detection of the tumor as well as the correct staging of disease are the key factors in the pancreatic cancer diagnosis. In the case of clinically suspected pancreatic cancer the most frequently used diagnostic methods are: ultrasound (US), endoscopic retrograde cholangiopancreatography (ERCP), computer tomography (CT).

The dynamic development of nuclear magnetic resonance techniques (MRI), especially the introduction of rapid breath-hold sequences, dynamic scanning after the administration of the contrast medium, as well as the introduction of the cholangiopancreatography of the magnetic resonance (MRCP), evoked a lot of interest in this new, non-invasive diagnostic method in the medical world.

In recent years a series of clinical researches have been implemented, which the final point was the comparison of the usefulness of MRI and MRCP to the commonly used diagnostic methods such as CT and ERCP [4–6].

The objectives of the thesis were:

- to assess the usefulness of the magnetic resonance (MRI) expanded by the cholangiopancreatography technique of the magnetic resonance (MRCP) in diagnosis of the patients who are suspected of having pancreatic carcinoma on the basis of clinical, laboratory and radiological examinations (US, CT).
- to define the usefulness of MRI and MRCP in the evaluation of resectability of pancreatic cancer in comparison to surgical findings.

Material and Methods

The research has been carried out in the Radiology Department as well as in the Clinic of General Surgery and Endocrinological of the Medical University in Białystok. The examination protocol was approved by local ethics committee at the Medical University in Białystok.

From January 2001 to September 2003, 49 patients referred to our hospital with a suspected pancreatic tumor. Of the 49 patients included in this study, 33 were men and 16 were women, ranging in the age between 44 and 82 years (mean age 65 years \pm 18). All patients had undergone to MRI and MRCP examination. The results were compared to histopathological examinations (n=36) or to the biopsy results (n=11) and to the surgical findings. Based on the MRI or MRCP examination the resectability of malignant tumor was assessed.

All MRI scans were obtained using a 1.5 T MRI scanner (Picker Edge Eclipse, Picker International Inc., Highland Heights, USA) with use of a standard flexible surface coil. Imaging sequences with T1-weighted FAST scan (TR 105 ms, TE 4.47 ms, 6 mm thick sections) pre and post i.v. contrast media administration (0.2 mmol/kg, Megnevist, Schering) were performed. Express T2-weighted series (TR 15000 ms, PTE 105, 6.5 mm thick sections) were used. MRCP was performed with heavily T2-weighted HASTE sequence (PTE 240 ms, TR 8000, 7mm thick sections). For better distinction between bile and intra- and retroperitoneal fat we used FatSat sequence (TE 4.47 ms, TR 160 ms, 6.5 mm thick sections). Each patient has fasted (including water) for 2 hours before examination. For better evaluation of the stomach and the duodenum some patients were given orally contrast medium Magnevist Enteral (Schering AG). The total study time averaged 20-30 min, breath hold 20 s per sequence.

The radiological assessment included: signal intensity alteration of pancreatic parenchyma; mass effect, tumor diameter; morphology of the pancreatic duct; morphology of the bile ducts; encasement of blood vessels; invasion of adjacent structures; assessment of lymph nodes; distant metastases.

MR imaging interpretation

The region within the pancreas was suspected of the presence of carcinoma when alterations of the proper anatomical contours of the organ were found. Especially with the presence of focus which signal intensity of the pancreatic parenchyma in the T1-weighted images was relatively decreased and it demonstrated hypointense, isointense or slightly hyperintense signal in T2-weighted sequences.

After the intravenous contrast media administration the area did not indicate enhancement. Early local invasion was suspected when in T1-weighted time changes in signal intensity of extra-peritoneal adipose tissue was observed.

As a more advanced local invasion the malignant infiltration of peri-pancreatic vessels was regarded. The vessel infiltration was very unlikely if less than one-quarter the circumference of the vessel was contiguous with the tumor. The case had to be considered equivocal if 25-50% the circumference of the vessel was contiguous with the tumor. There was a high likelihood of the vessel infiltration in cases in which more than one-half the circumference of the vessel was contiguous with the tumor. The presence of hydroperitoneum, enlargement of lymph nodes (the diameter above 1.0 cm) as well as distant metastases settled the question of unresectability of the tumor regardless of the local staging of the disease.

Surgical confirmation

The exactness of MRI and MRCP in the assessment of the staging of pancreatic cancer was compared to the surgical findings. The surgeon while performing an operation was informed about the results of radiological examination. Each parameter which influence the decision of tumor resectability were evaluated (infiltration of blood vessels, enlargement of lymph nodes, liver and/or peritoneum metastases). The operating surgeon classified the findings as positive or negative. The palpable mass detection within the pancreas fixed to peri-pancreatic blood vessels was regarded as the evidence of unresectability of the tumor. The size and localization of the changes was also evaluated. The liver and peritoneum inspection was carried out by means of palpable examination, visual assessment, as well as biopsy.

The final verification in relation to the operated patients (n=36) constituted histopathological examination of the collected intra-operatively material. It included the histopathological diagnosis with the assessment of the staging in case of the malignant process (according to TNM classification /*tumor-nodes-metastases*/) as well as the operative margin assessment. In the case of non-operated patients (n=10) cytological examination of biopsied specimens was performed.

Data analysis

The capacity of MR and MRCP was evaluated to:

- detection of pathological mass within pancreas,
- estimation of tumor size,
- accuracy of assessment of the disease process nature,
- accuracy of assessment of the resectability of the malignant lesion.

The lesions visualized in MR and MRCP examination was defined as malignant, benign or questionable and then they were compared to results of histopathological examination.

In order to assess the clinical usefulness of MR and MRCP in statistical analysis the following values were determined:

- sensitiveness – the ability to diagnose pathological cases in all patients,

- specificity – the general ability to confirm lack of disease in healthy patients,
- exactness – the general ability of the method for the detection of pathological cases as well as lack of presence of the disease,
- positive prediction index – determines the likelihood of disease confirmation in patients with positive test results,
- negative prediction index – determines the probability of disease exclusion on the basis of verification examination,
- Kappa index – determines compatibility of classification of the methods.

According to prediction of resectability of pancreatic carcinoma the patients were divided into four groups (Table 1):

I – true positive (TP) – patients subjected to operation, who did not indicate the infiltration of blood vessels or metastases, neither in MR and MRCP nor in the course of the operation,

II – true negative (TN) – patients, who on MR and MRCP examinations indicated the presence of the blood vessels infiltration or metastases within abdominal cavity, which was confirmed in laparotomy,

III – false positive (FP) – on the basis of MR and MRCP examinations the disclosed changes were determined as resectable, which was not confirmed during operation,

IV – false negative (FN) – patients who did not meet the criterion of resectability of the lesion in MR and MRCP examinations and who were next operated.

The unresectable cancer was judged as any tumor with accompanying metastases in liver, peritoneum, with the encasement of peripancreatic blood vessels, thrombosis of splenic vein, superior mesenteric or portal vein or local proliferation with affection of surrounding organs (other than duodenum) or enlargement of lymph nodes (above 1.0 cm – other than peripancreatic).

Resectable cancer was defined as any tumor judged to have been totally removed at surgery, without macroscopic evidence of residual tumor and without evidence of involvement of neighboring organs (other than duodenum) or hematogenous or distant lymph node metastases (other than peripancreatic nodes).

The remote survival assessment was possible in case of 20 patients affected with pancreatic carcinoma, who arrived at the follow-up examination.

The information about the patients were collected on individual forms and put in a computer database in Windows XP Professional Operational System. The thesis was written in Microsoft Office Word processor.

In the statistical analysis comparing qualitative features between the chosen groups the independence test X^2 and Fisher's precise test were performed, $p < 0.05$ was taken as the gravity level.

The results obtained on the basis of the collected material analysis were presented in tabular and graph forms.

Table 1. Diagnostic value of the test.

Test results	Pancreatic carcinoma	Absent of pancreatic carcinoma
Positive	TP	FP
Negative	FN	TN
True-positive ratio =	$\frac{TP}{TP+FN}$	
True-negative ratio =	$\frac{TN}{TN+FP}$	
Accuracy =	$\frac{TP+TN}{TP+FN+TN+FP}$	

TP – true positive; TN – true negative; FP – false positive; FN – false negative.

Results

The average age of 49 patients qualified for the examination was 65 (± 18). The clinic material constituted in 68% of men ($n=33$) and in 32% of women ($n=16$).

Histopathologically the following results were obtained: adenocarcinoma ($n=37$), serous cystadenoma ($n=2$), chronic pancreatitis with inflammatory tumor ($n=6$), lymphoma ($n=1$), cholangiocarcinoma ($n=1$).

The tumors were mainly localized within the head ($n=36$), body ($n=9$) and tail ($n=2$) of the pancreas.

Based on MR and MRCP examination, the presence of pathological mass within the pancreas was diagnosed in all patients. In 39 cases the nature of tumor was defined as malignant, in 6 cases as benign and in 2 as questionable. Out of the group of all patients with diagnosed malignant process, in 27 patients (69%) pancreatic tumor was qualified as unresectable on the basis of MR and MRCP assessment criteria, whereas in 12 cases (30%) the lesion within the pancreas were recognized as resectable.

In six cases the cause of unresectability of the lesion was the detection in MR examination metastases in the liver without visible features of infiltration of peripancreatic blood vessels. The local progression of the disease with the infiltration of blood vessels concerned 21 cases, and additionally metastatic foci in liver were revealed in 3 patients. In 15 cases the local vascular encasement was displayed. In 3 cases the infiltration of celiac trunk and superior mesenteric artery were revealed, in 2 patients cancerous process afflicted the portal and the mesenteric veins. In 1 case the contact of the tumor with the inferior vena cava and the superior vena cava walls was disclosed.

In three cases the infiltration of the celiac trunk and superior mesenteric artery were revealed, in two patients the cancerous process afflicted the portal and mesenteric veins.

In 1 case contact of the tumor with inferior vena cava wall was present.

In 16 patients in the MRI examination the presence of enlarged lymph nodes was determined.

In the majority of patients in the MRCP examination a good degree of visualization of bile ducts and pancreatic ducts was obtained. In 3 cases the images were not diagnostic enough due to the presence of liquid reservoirs within the epigastrium (n=1) or a lack of patient cooperation (n=2).

In the MRCP examination usually a sudden narrowing of the main pancreatic duct with the distal part extensions, and visible in some cases, extended secondary ducts were observed most frequently. In 14 cases (38%) the so called "double duct sign" – which is the extension of the common pancreatic duct and the intrahepatic bile ducts as well as the Wirsung's duct.

Out of 27 patients with the lesions qualified as unresectable according to MRI and MRCP assessment criteria, the laparotomy associated with the palliative operation was carried out in 24 patients. In those patients (n=24) a surgical verification confirmed the unresectability of the tumor. In 3 remaining patients a biopsy was performed. All patients with a MRI and MRCP confirmed unresectability of lesion (n=27), revealed the presence of adenocarcinoma when examined histopathologically. The MRI and MRCP imagination allowed the correct determination of the malignant nature as well as the unresectability of the tumor in the examined group of patients (n=27). The laparotomy revealed the presence of small metastases in the peritoneum in one of the patients, which were not detected by MRI.

The twelve patients, with the malignant tumor within the pancreas diagnosed on MRI and MRCP imagination, still meeting the criteria of resectability were consequently subjected to operation. A certain divergence occurred between the results of MRI and MRCP and the surgical findings in the 3 cases. In one of those cases the presence of metastases in the peritoneum and mesenteric lymph nodes was indicated, and in another one the tumor mass connection to the portal vein, which was not visualized on the MRI examination. In the last case the cause of divergences of the MRI results and laparotomy was the presence of the metastases in the group of mesenteric and hepatic lymph nodes as well as the superior mesenteric vein infiltration.

In one of the patients with inflammatory symptoms in the pancreas, after the administration of a paramagnetic contrast medium a hypointense area, suspected of the carcinogenic transformation, in T1-weighted sequence within the head of the pancreas was detected. Performed in this case histopathological analysis revealed the presence of lesion of the inflammatory nature.

In nine patients with the tumors based on MRI examination classified as respectable, without enlarged lymph nodes, whereas in 4 cases the presence of cancerous cells was stated in the samples of the neighboring lymph nodes.

In the group of twelve patients subjected to operation due to malignant nature of tumor but meeting the resectability criteria, histopathological examination stated: in 9 cases – adenocarcinoma, in 1 case – lymphopoma, in 1 case – cholangiocarcinoma of the intrapancreatic part of duct, and in 1 case – chronic inflammation with an inflammatory tumour.

In 2 patients the MRI and MRCP examinations revealed the presence of cystic lesion with a few septa within the pancreas head (lesion determined as questionable in the MRI examination). There was no possibility to exclude the presence of the malignant cystoid tumour (cystodeno-carcinoma) on the base of MRI imagination. In such cases a histopathological examination diagnosed the presence of benign lesions – the serous cystadenoma type.

Using the MRI and MRCP assessment criteria the presence of benign lesions (in the course of a chronic inflammation) was revealed in six patients.

In one case the MRI and MRCP imaging indicated the presence of a slightly narrowed pancreatic duct crossing the hypointense lesion as well as small cysts within the tumor mass which can correspond to the extended branches of the main duct. This tumor was classified (according to MRI and MRCP) as a benign one. The carried out biopsy revealed the presence of inflammatory tumor. The patient was then subsequently subjected to a long-term observation.

In one case with a histopathologically confirmed adenocarcinoma (T2 according to the TNM classification) certain inflammatory alterations were revealed through the MRI and MRCP examinations. The lesions within the head of the pancreas revealed in 4 remaining patients in the MRI and MRCP methods in T1-weighted sequence demonstrated a slightly reduced signal in comparison with the correct pancreatic parenchyma, of a heterogeneous enhancement on the sequences after contrast medium administration. In the MRCP the irregular extension of the main pancreatic duct was noticed accompanied by extended secondary ducts as well as with isolated pseudocysts and small areas of shortening of the T2 relaxation time. The biopsy and the histopathological examination proved the presence of inflammatory lesion. Those patients were later provided with a periodical medical control.

A statistical analysis carried out determined 87% sensitivity, 97% specificity and 95% exactness of MRI and MRCP in the evaluation of nature of tumors within the pancreas (Figure 1).

The MRI and MRCP imagination were marked by a 100% sensitivity, 90% specificity and 93% accuracy in determining the resectability of the lesion. The positive predictive value came to 83%, while the negative predictive value to 100%. The Kappa compatibility index in comparison with a surgical findings came to 0.85714.

In the evaluation of lymph nodes the MRI and MRCP were marked by 83% sensitivity, 56% specificity and 67% exactness. The positive predictive value came to 65%, whereas the negative predictive value came to 75% (Figure2).

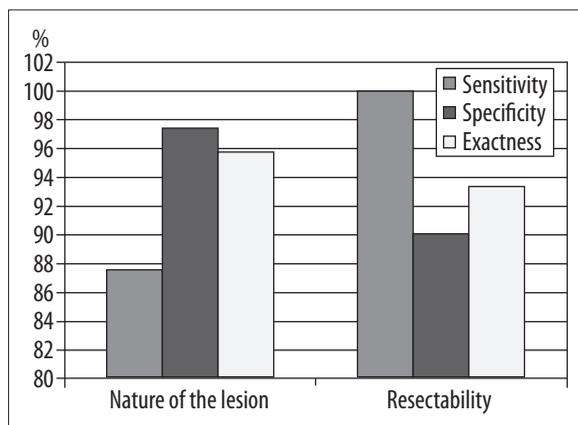


Figure 1. Sensitivity, specificity, and exactness of MRI and MRCP in determining the nature of a lesion and its resectability.

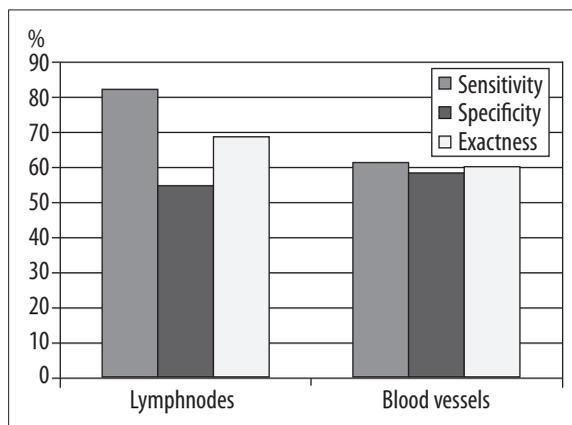


Figure 3. The average size of tumor mass in MR and in intraoperative findings.

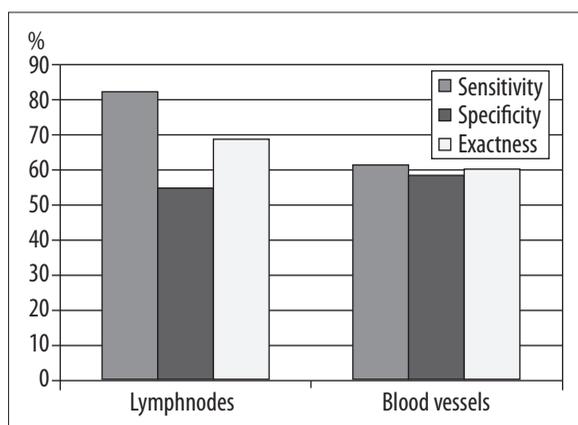


Figure 2. Sensitivity, specificity, and exactness of MRI and MRCP in the recognition of lymph node and blood vessel infiltration.

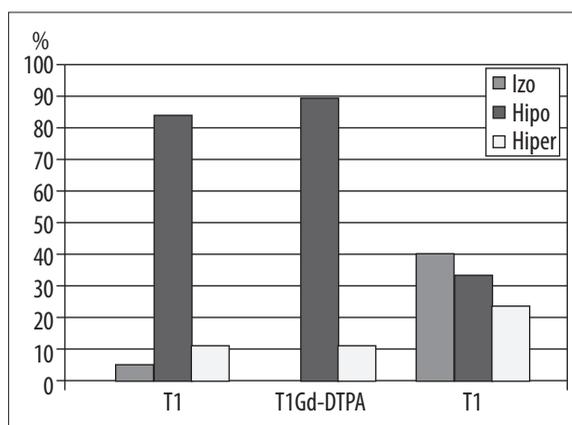


Figure 4. MRI signal intensity in T1-weighted time, in T1 after intravenous administration of a paramagnetic contrast medium (Gd-DTPA), and in T2-weighted time.

In the evaluation of blood vessels infiltration MRI were marked by 62% sensitivity, 58% specificity and 60% exactness (Figure 2). The positive prediction index came to 56%, while the negative prediction index came to 63%.

The size of the tumor detected within the pancreas in the MRI examination was compared with the size of tumor in the histopathological examination. The average size of the lesion in the MRI examination came to 2.7 ± 1.2 cm (2.0–6.0 cm), in the histopathological examination 3.9 ± 2 cm (1.5–9.0 cm) (Figure 3).

The lesion within the pancreas revealed the most frequently reduced intensity of the signal in T1 – weighted sequence compared to the correct pancreatic parenchyma, after an intravenous administration of Gd-DTPA did not undergo any contrasting reinforcement (hypointense signal). In T2-weighted sequence isointense signal was revealed by 41% of tumors, hypointense – 36% and hyperintense – 23% of pancreatic tumors (Figure 4).

Discussion

Adenocarcinoma deriving from the ductal epithelium is the most frequent form of pancreatic carcinoma and most frequently localizing within the head of the organ [7]. Pancreatic carcinoma is a disease connected with a high

mortality – no more than 3% of the suffering patients survives a 5-year period from time of diagnose was stated [8,9]. The majority of the affected patients dies within 1–2 years. In a study of 174 patients, Freeny found that the average survival rate after resection was 14 months, while the survival rate after palliative (biliary or gastrointestinal bypass) or no treatment were 8 months and 5 months, respectively [10]. The unfavorable prognosis is connected with an early spreading of cancerous cells beyond the pancreatic gland as well as the long period or asymptomatic development of the disease [3,11]. An early diagnosis of the tumor as well as the correct defining of the progression stage are of the key importance, as they are linked with undertaking the appropriate treatment. At this point of time only surgical treatment of early diagnosed tumors gives patients chance for recovering [3,12]. This, however concerns only a small percentage of those affected, in whose the presence of the cancerous lesion was diagnosed early, that is when the tumor diameter is no bigger than 2 cm, when the infiltration of peripancreatic blood vessels, enlarged lymph nodes and remote metastases is not determined (tumors T1a and T1b according to UICC classification). The appropriate preoperative determination of the pancreatic carcinoma staging allows for avoiding serious operations connected with a long hospitalization of the patients with an advanced stage of the disease [3,11].

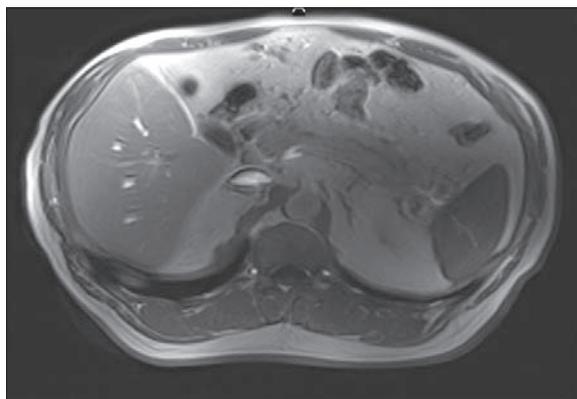


Figure 5. RF FAST T1-hypointense mass located in the head of the pancreas.

In case of a clinical suspicion of the pancreatic tumor new radiological non – invasive methods of imaging, such as US, CT, MRI have a special place and task. They serve either the exclusion or confirmation of the disease as well as determining stage of progression of the disease in order to single out a group of the ill with a localized cancerous process qualified for a surgical treatment [3,13,14]. In our centre, like in numerous other centers, the presence of remote metastases, the infiltration of blood vessels (other than peripancreatic) as well as a considerable local progression of the tumor with the affliction of adjacent organs (other than duodenum), and blood vessels in particular, are regarded as criteria of unresectability of the tumor.

In recent years the technology of nuclear magnetic resonance has been developing dynamically. The method does not utilize ionizing radiation and its additional merit is the possibility of multiplane examination planning, three-dimensional presentation of images. Contrast media (gadopentetate dimeglumine) used in the MRI examination may be safely administered to patients allergic to commonly used in radiology compounds containing iodine as well as in the case of patients with the impaired function of kidneys [15]. Furthermore, in the course of a single treatment, MRI allows for revealing venous and arterial peripancreatic vessels as well as bile ducts and the pancreatic duct without the necessity of applying contrast media [14].

Recently, the sequences successfully used in diagnostics of the pancreas diseases are the following: pulsating sequences of the spin echo in T1-weighted time with or without the fat saturation, gradient echo sequences with the breath held, with an intravenous administration of the contrast medium or without Gd-DTPA, conventional spin echo sequences and quick pulsating turbo spin echo sequences with the fat saturation in T2-weighted time as well as Flash sequences (fast low-angle shots) in T1-weighted time [4,16,17] (Figure 5). According to those authors, in many cases MRI allows for the detection of small, non – changing contours of the pancreas tumors. Enables the differentiation of a chronic inflammation with a normal findings as well as the chronic inflammation with a local enlargement (inflammatory tumor) with pancreatic cancer [4,16,17].

The most commonly encountered MRI image of the pancreatic carcinoma in our examinations was a pathological mass

with indistinct outlines and the diameter of approximately 3 cm revealing a reduced signal intensity in T1-weighted sequence in comparison to the correct pancreatic parenchyma (except lymphoma, which revealed the hyperintense signal) or the isointense signal (in three cases), which, most probably is connected to the presence of inflammatory alterations in the surrounding parenchyma. After the intravenous administration of Gd-DTPA the mass did not enhance and reveal hypointense signal in comparison with the remaining pancreatic parenchyma (Figure 5). Non-specific, extracellular paramagnetic contrast media improve a detection of pancreatic tumors due to obtaining appropriate contrast gradient between cancerously altered and richly vascularized parenchyma of the organ. The skimpy vascularization as well as the fibrous histological nature of the pancreatic carcinoma are responsible for the low intensity of the signal as well as indistinct, blurred contours of the tumor [17].

Revealing tumors in the T2-weighted sequence is more difficult because the lesions may bear the following signals: the isointense, the slightly hypointense or the hyperintense [18]. In the collected clinical material the isointense signal in the T2- weighted sequence was indicated by 41% of tumors, the hypointense by 36% and the hyperintense by 23% of tumors.

The local staging of the tumor and, in particular, its relation to the blood vessel structures, such as: the portal vein, the splenic vein, the superior mesenteric vein, the celiac trunk, the superior mesenteric artery, the hepatic artery, the inferior vena cava as well as the left kidney artery, belong to the most critical factors that decide about the tumor resectability [19–21].

In our own research material, when applied the criteria of the vessel infiltration of the afore-mentioned authors, the MRI indicated 62% sensitivity, 58% specificity, 60% accuracy.

The assessment of the liver is an important factor in the staging of pancreatic cancer patients, since pancreatic tumors tend to metastasize early into the liver [22]. The presence of at least one metastasis indicates a generalization of the disease and a unresectability of the tumor for the oncological reasons [1].

According to a number of authors the MRI examination strengthened by a contrast media plays an important part in a disclosure of metastases in the liver. [4,23]. This has also been confirmed by our research in which the metastases within the liver indicated non-specificity in the MRI examination. In the MRI method within the T1-weighted sequence those lesions indicated hypointense signal the most frequently before and after the contrast media had been applied intravenously, whereas in the T2-weighted sequence those lesions were slightly hyperintense with or without the central necrosis.

In the possessed research material the MRI indicated a low sensitivity in revealing metastases in the peritoneum. In the case of two patients the performed laparotomy pointed out to a presence of the tumor infiltrations in the peritoneum, which was not disclosed through the MRI method.

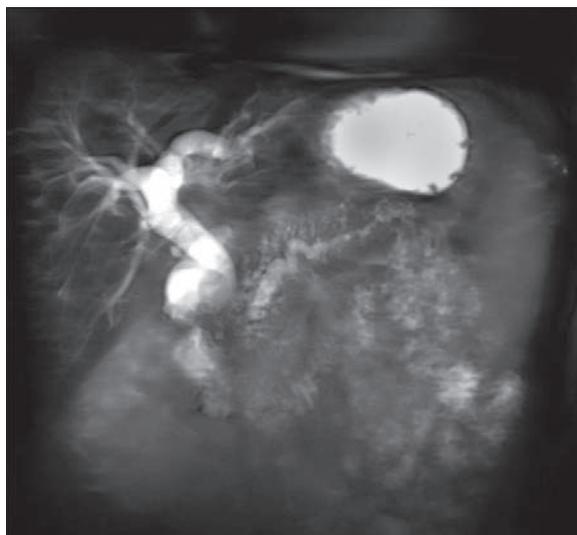


Figure 6. MRCP HASTE – “double duct sign”.

Thus, laparoscopy and laparotomy play an important part in the pancreatic carcinoma staging assessment, however, those are both invasive and costly methods. The metastases in the liver and peritoneum can be merely of several millimeters in size, thus invisible in the MRI examination [24].

Another important point in the diagnosis of pancreatic carcinoma is the assessment of the lymph nodes, in particular, the groups of the nodes other than peri-pancreatic (mesenteric, liver, etc.), in which the presence of metastases eliminates the occurrence of tumor resectability [22].

According to Ichikawa, whose assessment is based on the diameter of lymph nodes, the value of the negative predication of the MRI in the evaluation of lymph nodes is low and amounts to 57% [5].

In the collected research material the MR examination indicated the following values of the lymph nodes assessment: sensitivity 83%, specificity 55%, accuracy 67%. The index of the positive predication amounted to 65%, whereas its negative value 75%. In the group of patients, whose pancreas lesions were considered as resectable on the basis of MRI and MRCP examinations, 9 cases presented no enlargement of the lymph nodes, whereas 4 cases indicated the presence of metastases in the adjacent lymph nodes in the histopathological examination. It is difficult to detect the peripancreatic lymph nodes slightly enlarged because of the limitations of the resolution method and the presence of a number of minor structures (arteries, veins) in the peripancreatic area as well as a slight discrepancy in the signal intensity to the surrounding tissues [5]. In our clinical research by MRI method in the T1-weighted sequence the enlarged lymph nodes indicated an hypointense signal towards the surrounding fatty tissue, whereas in the sequences of fat saturation the signal was isointense. However, in T2-weighted, isointense signals of a higher or lower value were received and most frequently hypointense signals in the fat saturated sequences.

Enriching the conventional MRI examination of the abdominal cavity with an MRCP examination, based on the use of

quick sequences in the T2-heavily weighted time, provides invaluable data as to the condition of the bile duct and the pancreatic duct [25].

In the possessed clinical material a projection technology HASTE was applied for the hydrography of the MRI method (Figure 6).

Owing to the availability of a multiplane examination, the MRCP method allows for an exact depiction of the location of the stenosis, extent, and degree as well as the assessment of the segmental and/or extensive irregularities of the bile duct and the pancreatic duct, depending on the size and location of the pancreatic tumor [25,26]. The discrete duct alterations seen in the MRCP method may be of great weight for the diagnosis of minor, indiscrete pancreatic tumors as well as in the differential diagnosis of a chronic inflammation [26,27].

In the possessed research material the typical duct alterations to be observed in the patients ill with pancreatic carcinoma were the following: a sudden closure of the pancreatic duct (50%), an irregular stenosis frequently followed by a sudden extended proximal segment of the main duct with, either extended or not, minor secondary ducts and so called a “double duct sign” (Figure 6). The “*Double duct sign*” refers to both the extension of the bile duct and the pancreatic duct. This quality was observed in 14 out of 37 patients ill with pancreatic carcinoma (38%). The obtained images of the bile duct and the pancreatic duct referring to the staging of the pancreatic carcinoma correspond to those data reported by other authors [28,29].

The carried out research showed that MRI in connection with MRCP indicate a high accuracy in the detection of the presence of a pathological mass in the pancreas (100%), description of its character and assessment of the staging degree of the pancreatic carcinoma. In the statistical analysis a high Kappa index was obtained in comparison with the intra-operative imaging (0.85714) as to the evaluation of resectability lesions. The unresectability of malignant tumors indicated on the basis of the MR evaluation criteria enriched with a sequence of MRCP was confirmed by laparotomy in all the patients (n=27). The diagnostic mistakes dealt with the group named as the falsely negative, but not the falsely positive one.

Estimating tumor size in preoperative staging of pancreatic carcinoma showed a tendency to understage tumor size in this study population what is also conclusive with findings of Bley TA et al [30].

In the case of the pathological mass diagnosis within the pancreas the most difficult diagnostic problem is to differentiate a cancer from an inflammatory tumor. No radiological diagnostic method can grant a 100% certainty of the diagnosis accuracy [31,32]. The diagnosis as well as the performance of an appropriate differentiation is a particularly responsible task as a distant prognosis and a therapeutic procedure in both diseases differ significantly. In the case of the chronic inflammation the aim of the surgery (by Berger's or Frey's method) is to eliminate the pain and other symptoms, whereas in the pancreatic carcinoma the objec-

tive of a surgery is to remove the carcinogenic tissue (by Whipple's method).

It is not easy to differentiate between a cancer and an inflammatory tumor for the reason that the pancreatic carcinoma is frequently accompanied by secondary inflammatory alterations, which affects the parenchyma signal intensity in the MRI examination. On the other hand, a cancer may develop from the chronic inflammatory alterations, the occurrence of which poses a higher risk of cancer [32,33].

Relatively frequent is the indication of the chronic inflammation alterations connected with a disturbed outflow of the pancreatic juice in the pancreatic duct cancer [34]. A small tumor located in the proximity of the pancreatic duct, indiscernible in the radiological examinations, may cause the duct's narrowing as well as its acute inflammatory condition in the gland. Moreover, the inflammatory alterations can lead to the mistakes as to the assessment of the size of the tumor. It is also to be underlined that a developing inflammation process may on many occasions be the cause of local lymphadenopathy, which may indicate the presence of metastasis in the lymph nodes [32].

The clinical symptoms reported by the patients with a chronic inflammation, such as returning fits of an acute pain in the upper abdomen, also to be felt in the back, a decline in the body weight, all the symptoms connected with narrowing of the common bile duct, the pancreatic duct or the duodenum prevail in the clinical picture of both the chronic inflammation and the pancreatic carcinoma [35]. The adenocarcinoma to be found in approximately 70% within the head of the pancreas shows a similar localization to the chronic inflammatory alterations.

Despite an enormous progress in the development of radiological imagination, to have occurred in the last decade, none of the modern diagnostic methods can be considered a 100% accuracy method in differentiating a pancreatic carcinoma from an inflammatory tumor [35]. Certain symptoms, for instance, the presence of calcifications dispersed in the pancreas parenchyma as well as the images of extended duct structures within the tumor mass showed by MRCP examination speak in favor of an inflammatory tumor occurrence [21]. In the studies conducted by Van Gulik and partners out of 220 pancreato-duodenectomy examinations conducted for the cause of a pancreatic carcinoma detection, a chronic inflammation was diagnosed in the 6% of patients by the histopathological examinations [36]. Whereas Moussa and partners reported that out of 64 patients, operated on because of the chronic pancreatic inflammation, the presence of cancer was confirmed histopathologically in 4 cases [37]. However, in Zagrafos and partners the pancreatic carcinoma was diagnosed in 4 cases out of 250 altogether [35].

In the conducted research the presence of a chronic inflammation with an inflammatory tumor was diagnosed in the pancreas head in 6 patients aged 40–50. In the MRI examinations in the T1-weighted sequence those lesions showed a slightly decreased or a relatively increased signal intensity compared to the pancreas parenchyma, and in the sequences performed with the use of Gd-DTPA revealed an impaired

contrast enhancement. In MRCP examinations irregular extensions of the main pancreatic duct, distal to the narrowing place, as well as the extended secondary ducts together with pseudocysts were frequently observed. In all patients a good degree of the Wirsung's duct vision was obtained together with the duct's side branches extended all along their lengths. Only the presence of the pancreatic pseudocysts seemed to cause segmental disturbance of the pancreatic ducts vision. Those cases required a greater number of MRCP scans from a variety of angles in relation to the pilot scans.

In the clinical group (n=48) in MRI and MRCP the presence of cancerogenic lesions was mistakenly diagnosed in the case of 1 patient with the features of pancreatic inflammatory alterations. A hypointense area with irregular contours bearing all features of cancerogenic alterations were revealed within the head in the T1-weighted sequence. The conducted histopathological analysis indicated the presence of alterations of the inflammatory type. In the case of another patient, who showed a presence of adenocarcinoma (T2 according to TNM classification), the MRI and MRCP examinations indicated the inflammatory alterations incorrectly.

On the basis of the conducted studies it appears that the MRI and MRCP examinations are to be applied as the diagnosis enrichment when despite all clinical and laboratory symptoms in favor of the presence of pancreatic carcinoma, the disease picture is still equivocal in other radiological methods. For the sake of a higher accuracy in describing the disease staging degree the MRI and MRCP examinations ought to be carried out for those pancreatic carcinoma patients who face a surgery. The MRI and MRCP examinations seem to be indispensable in the differential diagnosis of an inflammatory tumor and a cancer [27,38].

The MRI supplemented by a MRCP sequence provides an opportunity of a complex evaluation of the upper abdomen that can outperform, in certain aspects, the other applied methods. The MR sequences allow to receive images of any diameter, in fact, in two complementary diagnostic times – T1 and T2. Multi-sequential MR/MRCP examination is capable of combining the assets of the invasive methods and becoming a decisive method in a number of difficult diagnostic cases.

In conclusion, the MR and MRCP examinations fulfill the criteria of their applicability to the pancreatic carcinoma diagnosis thanks to the high sensitivity, specificity, and accuracy.

Conclusions

1. The Magnetic Resonance (MR) connected with the Magnetic Resonance Cholangiopancreatography (MRCP) is suitable method in the diagnosis and assessment of respectability of pancreatic tumors.
2. MR and MRCP are an accurate, high specify and noninvasive technique in the preoperative evaluation of pancreatic malignancy, particularly useful in the differential diagnostics and treatment decision.

References:

1. Warshaw AL, Gu ZY, Wittenberg J, Waltman AC: Preoperative staging and assessment of resectability of pancreatic cancer. *Arch Surg*, 1990; 125: 230-33
2. Megibow AJ: Pancreatic adenocarcinoma: designing the examination to evaluate the clinical questions. *Radiology*, 1992; 183: 297-303
3. Stephens DH: Pancreatic adenocarcinoma. *Abdom Imaging*, 1996; 21: 207-10
4. Megibow AJ, Zhou XH, Rotterdam H et al: Pancreatic adenocarcinoma: CT versus MR imaging in evaluation of resectability – Report of the Radiology Diagnostic Oncology Group. *Radiology*, 1995; 195: 327-32
5. Ichikawa T, Haradome H, Hachiya J et al: Pancreatic ductal adenocarcinoma: preoperative assessment with helical CT versus dynamic MR imaging. *Radiology*, 1997; 202: 655-62
6. Takehara Y, Ichijo K, Tooyama N et al: Breath-hold MR cholangiopancreatography with a long-echo-train fast spin-echo sequence and a surface coil in chronic pancreatitis. *Radiology*, 1994; 192: 73-78
7. Klöppel G, Solcia E, Longnecker D et al: *Histologic Typing of Tumors of the Exocrine Pancreas*, 2nd ed. Berlin: Springer Verlag, 1996
8. Landis SH, Murray T, Bolden S et al: Cancer statistics. *Ca cancer J Clin*, 1999; 49: 8-31
9. Fernandez E, La Vecchia C, Porta M et al: Trends in pancreatic cancer mortality in Europe, 1955-1989. *Int J Cancer*, 1994; 57: 786-92
10. Freeny PC, Marks WM et al: Pancreatic Ductal Adenocarcinoma: Diagnosis and staging with dynamic CT. *Radiology*, 1988; 166: 125-33
11. Pour PM: The silent killer. *Int J Pancreatol*, 1991; 10: 103-4
12. Livingston EH, Welton MI, Reber HA: Surgical treatment of pancreatic cancer: the United States experience. *Int J Pancreatol*, 1991; 9: 153-57
13. Frager D: Pappillary tumors of the pancreas and expanding magnetic resonance cholangiopancreatography. *Am J Gastroenterology*, 1998; 93(2): 137-38
14. Hochwald SN, Rofsky NM et al: Magnetic resonance imaging with magnetic resonance cholangiopancreatography accurately predicts resectability of pancreatic carcinoma. *J Gastrointestinal Surg*, 1999; 3: 506-11
15. Puchalski Z, Ładny JR, Polaków J et al: Diagnosis and surgical treatment of pancreatic carcinoma. *Roczniki Akademii Medycznej w Białymstoku*, 1996; 41: 210
16. Imanishi Y, Hou VY, Chako C et al: Evaluation of the pancreas by MRI. *Eur Radiol*, 1994; 4: 243-53
17. Müller ME, Meyenberger Ch, Bertschinger Ph et al: Pancreatic tumor: evaluation with endoscopic US, CT, and MR imaging. *Radiology*, 1994; 190: 745-51
18. Kelekis NL, Semelka RC: MRI of pancreatic tumor. *Eur Radiol*, 1997; 7: 875-86
19. Loyer EM, David CL, Dubrow RA et al: Vascular involvement in pancreatic adenocarcinoma: reassessment by thin-section CT. *Abdom Imaging*, 1996; 21: 202-6
20. Lu DSK, Reber HA, Krasny RM et al: Local staging of pancreatic cancer: criteria for unresectability of major vessels as revealed by pancreatic-phase thin section helical CT. *Am J Roentgenol*, 1997; 168: 1439-43
21. O'Malley ME, Boland GWL, Wood BJ et al: Adenocarcinoma of the head of the pancreas: determination of surgical unresectability with thin-section pancreatic phase helical CT. *Am J Roentgenol*, 1999; 173: 1513-18
22. Warshaw AL, Fernandez-del Castillo C: Pancreatic carcinoma. *N Engl J Med*, 1992; 326: 455-65
23. Bluemke DA, Fishman EK: CT and MR evaluation of pancreatic cancer. *Surg Oncol Clin North Am*, 1998; 7: 103-24
24. Fernandez-del Castillo C, Warshaw AL: Laparoscopic staging and peritoneal cytology. *Surg Oncol Clin North Am*, 1998; 204: 513-520
25. Warshaw AL, Fernandez-del Castillo C: Pancreatic carcinoma. *N Engl J Med*, 1992; 326: 455-65
26. Laubenberg J, Buchert M, Schneider B et al: Breath-hold projection magnetic resonance cholangio-pancreatography (MRCP): a new method for the examination of the bile and pancreatic ducts. *Magn Reson Med*, 1995; 33: 18-23
27. Ichikawa T, Sou H et al: Duct-penetrating sign at MRCP: usefulness for differentiating inflammatory pancreatic mass from pancreatic carcinomas. *Radiology*, 2001; 221(1): 107-16
28. Adamek HE, Albert J, Breer H et al: Pancreatic cancer detection with magnetic resonance cholangio-pancreatography and endoscopic retrograde cholangiopancreatography: a prospective controlled study. *Lancet*, 2000; 36: 190-93
29. Pavone P, Laghi A, Catalano C et al: MR cholangiopancreatography (MRCP) at 1.5 T: technique optimization and preliminary results. *Eur Radiol*, 1996; 6: 147-52
30. Bley TA, Uhl M, Simon P et al: Diagnostic accuracy of MRI for preoperative staging of pancreatic carcinoma: tendency for understaging. *In vivo*, 2005; 19(6): 983-87
31. Haven F, Bloemen H, Van Hoe L: Chronic pancreatitis with enlargement of the pancreatic head: new specific signs on cross-sectional and projective magnetic resonance cholangio-pancreatography. *Eur Radiol*, 1999; 9: S143(suppl)
32. Talamini G, Falconi M, Bassi C et al: Incidence of cancer in the course of chronic pancreatitis. *Am J Gastroenterol*, 1999; 94(5): 1253-60
33. Amman RW, Knoblauch M, Mohr P, Deyhle P: High incidence of extrapancreatic carcinoma in chronic pancreatitis. *Scand J Gastroenterol*, 1980; 15: 395-99
34. Takehara Y: Can MRCP replace ERCP? *J Magn Reson Imaging*, 1998; 8(3): 517-34
35. Zografos GN, Bean AG, Williamsin CN: Chronic pancreatitis and neoplasia: Correlation and coincidence. *HPB Surgery*, 1997; 10: 235-39
36. Van Gulik TM, Reeders JW, Bosma A et al: Incidence and clinical findings of benign, inflammatory disease in patients resected for presumed pancreatic head cancer. *Gastrointest Endosc*, 1997; 46: 417-23
37. Moussa AR, Levine B: The diagnosis of early pancreatic cancer. *Cancer*, 1981; 47: 1688-97
38. Schima W: MRI of the pancreas: tumors and tumor-simulating processes. *Cancer Imaging*, 2006; 6: 199-203