Main Pancreatic Duct Intraductal Papillary Mucinous Neoplasms: Accuracy of MR Imaging in Differentiation between Benign and Malignant Tumors Compared with Histopathologic Analysis

Purpose: To retrospectively determine the accuracy of magnetic resonance (MR) imaging combined with MR cholangiopancreatography (CP) in differentiating benign from malignant intraductal papillary mucinous neoplasms (IPMNs) involving the main pancreatic duct (MPD), with histopathologic analysis as the reference standard.

Materials and Methods: The informed consent requirement was waived for this institutional review board–approved study. A total of 51 patients with histopathologically proved IPMNs (MPD IPMN, n = 29; mixed type IPMN, n = 22), underwent MR imaging, MR CP, and surgery, with a mean interval of 2.6 months between MR examination and surgery. Qualitative image analysis included assessment of the site of MPD dilatation (head of the pancreas, body and/or tail of the pancreas, or diffuse), presence or absence of duct wall nodules, and contrast enhancement of the MPD walls. Quantitative image analysis included measurement of the maximum diameter of the MPD. A comparison of adenomas and borderline IPMNs with cancerous IPMNs was performed with the Student t test or the Mann-Whitney U test for continuous variables.

Results: At histopathologic analysis, 27 IPMNs were classified as carcinomas; 13, as borderline tumors; and 11, as adenomas. MPD wall nodules were observed in 16 carcinomas involving the MPD and one adenoma or borderline neoplasm (P < .00001). Duct wall enhancement was observed in 20 MPD or mixed type carcinomas and five adenomas or borderline neoplasms (P = .0001). The median maximal diameter of the MPD was 18 mm in malignant MPD or mixed type IPMNs and 11 mm in benign borderline IPMNs (P = .038). No significant difference in the overall 5-year survival rate of patients with MPD IPMNs and those with mixed type IPMNs was observed (P = .813).

Conclusion: Duct wall nodules and enhancement of the MPD walls are signs of malignant MPD or mixed type IPMNs.

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Intraductal papillary mucinous neoplasms (IPMNs) of the pancreas originate from the mucinous epithelium of the pancreatic duct system and are characterized by papillary growth and hyperproduction of mucin, causing duct dilatation (1,2).

The gross appearance of these tumors depends on the site of origin along the pancreatic duct system: We can distinguish between IPMNs of the main pancreatic duct (MPD) (both those with segmental involvement and those with diffuse involvement), IPMNs of the side branches, and IPMNs of both the MPD and the side branches (mixed type) (3). At histologic analysis, IPMNs are classified as adenomas, borderline tumors, or carcinomas depending on the degree of cytarchitectural atypia (4,5).

Malignancy can occur as an in situ or invasive cancer in 30%–88% of IPMNs (6). A stepwise progression of different degrees of dysplasia in the same tumor (4,7–9). The risk of malignant degeneration correlates with the site of tumor origin: For MPD IPMNs, the mean risk is 70% (range, 57%–85%) (6,7,9,10); however, for side branch IPMNs, the mean risk is 25% (range, 6%–46%) (9,11–15). It is assumed that the risk of malignant degeneration of mixed type IPMNs is similar to that of MPD IPMNs; however, to our knowledge, there are no published findings to confirm this likely hypothesis. Because of this different biologic behavior and prognosis, surgery is indicated in patients with IPMNs involving the MPD (7,16,17); therefore, preoperative characterization of IPMNs as adenomas, borderline tumors, or carcinomas is needed to properly select candidates for surgical procedures and help the surgeon plan the timing, type, and extent of resection.

There are clinical parameters—such as recent onset of jaundice, diabetes, weight loss, and abdominal pain—and tumor markers—such as carcinoembryonic antigen and Ca19-9 levels—that may help to predict malignancy. However, these cannot be used to reliably distinguish benign IPMNs from malignant IPMNs involving the MPD because they widely overlap (7,18). For this reason, imaging criteria have been proposed for use in lesion characterization. These include MPD caliber of at least 15 mm, diffuse dilatation of the MPD, mural-based nodules, and contrast enhancement of the duct wall. These features have been reported in series that grouped MPD IPMNs, mixed type IPMNs, and side branch IPMNs (11, 19–21).

Magnetic resonance (MR) imaging is potentially the most accurate imaging method used to depict these signs because it can be used to simultaneously investigate pancreatic parenchyma with cross-sectional imaging and the pancreatic duct system with MR cholangiopancreatography (CP) (19,22).

The primary objective of our study was to retrospectively determine the accuracy of MR imaging combined with MR CP in differentiating benign from malignant IPMNs involving the MPD, with histopathologic analysis as the reference standard. The secondary objective was to compare the biologic behavior and prognosis of MPD and mixed type IPMNs.

**Implications for Patient Care**

- Because of their prognosis, patients with an IPMN involving the MPD (MPD or mixed type IPMN) are candidates for surgery, unlike those with a side branch IPMN; preoperative identification of predictors of malignancy helps when planning the type and extent of surgery, especially in elderly patients with comorbidities and in whom surgery may pose increased risks.

- Patients with mixed type IPMNs should be candidates for surgery, analogous to patients with MPD IPMNs, since the two groups of patients do not show any difference in terms of the 5-year survival rate.
was waived. A search of our institution’s medical records and pathology and radiology databases for records from January 2001 through December 2005 revealed 185 patients in whom IPMN was diagnosed and who were subsequently considered for inclusion in this retrospective study.

Patients were included if they had histopathologically proved MPD and had undergone a surgical procedure and preoperative MR imaging and MR CP. Patients were excluded if they had undergone diagnostic imaging at another institution (n = 66), they had side branch IPMN (n = 48), they had undergone previous surgery on the pancreatic gland (n = 16), or the MR images were of poor quality (n = 4). Thus, our study population consisted of 51 patients (mean age, 62.4 years; age range, 31–81 years), 32 of whom were men (mean age, 62.9 years; age range, 31–80 years) and 19 of whom were women (mean age, 61.5 years; age range, 36–81 years).

The clinical findings and laboratory data of the patient population at the time of diagnosis are summarized in Table E1 (Table E1 [online]). Of note, five (10%) of 51 patients were asymptomatic, and the diagnosis of MPD IPMN was made at diagnostic imaging performed for other reasons.

All patients underwent MR imaging, MR CP, and a surgical procedure. The mean interval between (a) MR imaging and MR CP and (b) surgery was 2.6 months (range, 1 day to 20 months). Surgery was indicated by clinical signs and symptoms, laboratory data that were indicative of malignancy, and imaging findings. At surgery, 27 (53%) of the 51 patients underwent pancreatecoduodenectomy; 17 (33%), distal pancreatectomy; and seven (14%), total pancreatectomy. The type of resection was determined according to the site of the tumor, as indicated by preoperative examination findings, and the extent of surgical resection was determined according to the results of frozen section examination of the cut surface during the surgical procedure (23). The median follow-up time was 29.5 months (mean, 36 months; range, 4–127 months).

**MR Imaging**

MR imaging was performed with a 1.5-T imager (Magnetom Symphony; Siemens, Erlangen, Germany) and use of a four-channel phased-array coil. The patients were asked to fast for 4–6 hours before the examination. Furthermore, to eliminate overlapping fluid-containing organs on T2-weighted images, a negative contrast agent was administered before MR imaging. This consisted of administration of 50–150 mL of superparamagnetic iron oxide particles (ferumoxsil, Lumirem; Guerbet, Aulnay-sous-Bois, France) 10–20 minutes before the start of the examination. No antiperistaltic drug was administered.

The MR protocol included the following elements (Table 1): A chemical-shift T1-weighted gradient-echo sequence was performed with in- and out-of-phase echo times in the axial plane, a fat-saturated T2-weighted RARE sequence was performed in the axial plane, and a T2-weighted half-Fourier RARE sequence was performed in the coronal and axial planes.

<table>
<thead>
<tr>
<th>Table 1</th>
<th>MR Imaging Protocol</th>
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<tr>
<td>Pulse Sequence</td>
<td>Imaging Plane</td>
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<tr>
<td>Chemical shift T1-weighted gradient echo</td>
<td>Axial</td>
</tr>
<tr>
<td>Fat-saturated T2-weighted RARE</td>
<td>Axial</td>
</tr>
<tr>
<td>T2-weighted half-Fourier RARE</td>
<td>Coronal and axial</td>
</tr>
<tr>
<td>T2-weighted half-Fourier RARE</td>
<td>Sagittal and coronal oblique</td>
</tr>
<tr>
<td>Two-dimensional half-Fourier RARE MR CP</td>
<td>Coronal oblique</td>
</tr>
<tr>
<td>Respiratory-triggered three-dimensional half-Fourier RARE MR CP</td>
<td>Coronal</td>
</tr>
<tr>
<td>Three-dimensional volumetric gradient-echo VIBE</td>
<td>Coronal</td>
</tr>
</tbody>
</table>

Note.—RARE = rapid acquisition with relaxation enhancement, VIBE = volumetric interpolated breath-hold examination.
chelates (MultiHance, Bracco, Milan, Italy; Magnevist, Schering, Berlin, Germany) with a power injector (Spectris; Medrad, Pittsburgh, Pa) at a rate of 2–2.5 ml/sec; images were acquired in the precontrast, pancreatic (35–45 seconds after injection), portal venous (75–80 seconds after injection), and delayed (>180 seconds after injection) phases.

**Image Analysis**

MR and MR CP images were independently analyzed by two radiologists (R.M., R.G.; 15 and 20 years of experience in gastrointestinal radiology, respectively) who were aware of the diagnosis of IPMN involving the MPD but were unaware of the histopathologic diagnosis (lesion location and type [adenoma or borderline carcinoma]). Subsequently, image interpretation discrepancies were resolved by consensus; this was required for 30 (20%) of the 153 parameters analyzed. Image analysis was performed at a workstation. Quantitative image analysis was performed by a radiologist who was not involved in the qualitative image analysis (S.B., 5 years of experience) at a workstation with an electronic caliper.

Qualitative image analysis included assessment of the following parameters: site of dilatation of the MPD (dilatation of the head, body, and/or tail of the pancreas or diffuse dilatation), presence or absence of duct wall nodules (endoluminal filling defects adjacent to the nondependent duct wall seen on either T2-weighted MR images or postcontrast fat-suppressed T1-weighted MR images), and signal intensity enhancement of the MPD walls on postcontrast fat-saturated T1-weighted MR images compared with that on precontrast MR images. Endoluminal filling defects adjacent to the dependant wall of the MPD were not considered for image analysis because of the difficult differential diagnosis between mucin or protein plugs and duct wall nodules.

Quantitative image analysis included measurement of the maximum diameter of the MPD and the maximum diameter of the MPD wall nodules. We considered the upper limits of MPD diameter to be 5, 4, and 3 mm in the head, body, and tail of the pancreas, respectively (24). The MR and MR CP findings were subsequently compared with the histopathologic data.

**Histopathologic Analysis**

The pancreatic specimens were dissected along the MPD and then fixed in a 10% formaldehyde solution. The entire portion of the resected pancreas was included and examined with a light microscope. The histopathologic type and extent of the intraductal papillary mucinous pancreatic tumor, the involvement of the MPD, and the histopathologic status of the final pancreatic cut surface were systematically assessed by a pathologist (P.C., 18 years of experience).

At histopathologic analysis, epithelial lesions of the MPD IPMNs were classified into three histopathologic subtypes—adenoma, borderline tumor, and adenocarcinoma—according to the World Health Organization classification system (5,9). The correlation between clinical presentation and histopathologic features is reported in Table E1 (Table E1 [online]). Subsequently, histopathologic and gross morphologic findings in the surgical specimen were compared with the imaging findings by a pathologist (P.C.) and a radiologist (M.M.). The histopathologic examination was the reference standard in this study.

**Statistical Analyses**

Interobserver variability in determining the site of dilatation of the MPD, presence or absence of duct wall nodules, and enhancement of the MPD walls was assessed with κ statistics. The strength of agreement was assessed as follows: a κ value of less than 0.20 indicated poor agreement; a κ value of 0.21–0.40, fair agreement; a κ value of 0.41–0.60, moderate agreement; a κ value of 0.61–0.80, good agreement; and a κ value of 0.81–1.00, excellent agreement. The distributions of continuous variables are reported as medians and interquartile ranges (25th and 75th percentiles). Categorical variables are presented as numbers and percentages. The main outcome considered was histopathologic diagnosis of carcinoma.

For data analysis, benign and borderline tumors were grouped together as benign tumors. The comparison between subgroups, which were identified by status at histopathologic diagnosis (adenoma, borderline tumor, or carcinoma), was performed with the Student t test (patient age) and the Mann-Whitney U test (diameter of the MPD) for continuous variables. Qualitative data were compared with the χ² or Fisher exact tests, when necessary. In 51 patients who underwent resection, multivariate analysis was performed with the binary logistic regression model to evaluate the relative role of the MR imaging parameters in predicting malignancy. Survival was defined as the time from surgical resection to death and was considered the last follow-up date if no events had occurred. Survival probability was estimated with the Kaplan-Meier method, whereas the log-rank test was used for univariate survival analysis in different subgroups. P < .05 was considered indicative of a significant difference.

**Results**

At histopathologic examination of the surgical specimen, 27 (53%) of the 51 IPMNs were classified as carcinomas, 13 (25%) were classified as borderline tumors, and 11 (22%) were classified as adenomas involving the MPD. Of the 51 IPMNs, 29 (57%) involved only the MPD, whereas the remaining 22 (43%) also involved the side branches (mixed type). A further analysis of the histopathologic features of the IPMNs is reported in Tables E1 and E2 (Tables E1, E2 [online]).

**Qualitative Image Analysis**

*Site of ductal dilatation.*—Dilatation of the MPD was diffuse in 30 (59%) of the 51 patients (Fig 1) localized to the body or tail of the pancreas in 15 (29%) patients, and localized to the head of the pancreas in six (12%) patients (Figs 1, 2). The interobserver agreement in assessing the site of ductal dilatation was good (κ = 0.689).
Of the 27 patients with intraductal papillary mucinous carcinomas, 20 (74%) had diffuse dilatation of the MPD (Fig 1), six (22%) had localized dilatation of the body or tail of the pancreas (Fig 2), and one (4%) had localized dilatation of the head of the pancreas (Table 2). Of the 24 patients with a histopathologic diagnosis of intraductal papillary mucinous adenoma or borderline neoplasm, 10 (42%) had diffuse dilatation of the MPD, nine (38%) had dilatation of the MPD localized to the body or tail of the pancreas, and five (21%) had dilatation of the MPD localized to the head of the pancreas (Table 2). Further data on the site of ductal dilatation in the group of patients with malignant tu-

Table 2

<table>
<thead>
<tr>
<th>MPD and Mixed Type IPMNs</th>
<th>MR and MR CP Finding</th>
<th>Adenoma (n = 11)</th>
<th>Borderline (n = 13)</th>
<th>Carcinoma (n = 27)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean caliber MPD (mm)*</td>
<td>20 (8–40)</td>
<td>10 (4–30)</td>
<td>34 (7–180)</td>
<td>.038</td>
<td></td>
</tr>
<tr>
<td>MPD dilation site</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Head of the pancreas</td>
<td>1 (9)</td>
<td>4 (31)</td>
<td>1 (4)</td>
<td>.169</td>
<td></td>
</tr>
<tr>
<td>Body or tail of the pancreas</td>
<td>6 (55)</td>
<td>3 (23)</td>
<td>6 (22)</td>
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<tr>
<td>Diffuse</td>
<td>4 (36)</td>
<td>6 (46)</td>
<td>20 (74)</td>
<td></td>
<td></td>
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<tr>
<td>MPD mural nodules</td>
<td>0</td>
<td>1 (8)</td>
<td>16 (59)</td>
<td>&lt;.00001</td>
<td></td>
</tr>
<tr>
<td>MPD wall enhancement</td>
<td>1 (9)</td>
<td>4 (31)</td>
<td>20 (74)</td>
<td>.0001</td>
<td></td>
</tr>
</tbody>
</table>

Note.—Unless otherwise indicated, data are numbers of patients, and data in parentheses are percentages. P values were calculated for comparison of adenomas or borderline IPMNs with malignant IPMNs.

* Data in parentheses are ranges.
Figure 2: (a, b) MR CP and MR images show endoluminal filling defects in a 66.9-year-old man with MPD IPMN. (a) Coronal T2-weighted half-Fourier RARE MR CP image (2100/1100) shows segmental dilatation of the MPD localized to the tail of the pancreas (arrows). (b) In the corresponding transverse fat-suppressed RARE T2-weighted MR image (4500/102), an endoluminal filling defect can be observed in the tail of the MPD, adjacent to the dependent wall (arrow). An acute angle can be observed between the MPD wall and the endoluminal filling defect, indicative of a protein plug or mucin. Benign changes of the main pancreatic wall epithelium were detected at histopathologic analysis.

Figure 3: (a–e) MR and MR CP images in a 58-year-old woman show mixed type IPMNs involving both the MPD and the side branches. (a) Coronal oblique maximum intensity projection of a three-dimensional T2-weighted half-Fourier RARE (652) MR CP image shows diffuse dilatation of the MPD and side branches involving the entire length of the pancreas. (b) Axial T2-weighted half-Fourier RARE (652) MR image shows a duct wall nodule adjacent to the non-dependent wall of the dilated MPD (arrow). (c) Axial precontrast fat-saturated T1-weighted gradient-echo MR image (4.5/1.7) shows a hypointense parietal nodule (arrow). (d) Axial gadolinium-enhanced fat-saturated T1-weighted gradient-echo MR image (4.5/1.7) shows enhancement of the parietal nodule (arrow). (e) The MPD wall nodule was an adenocarcinoma, as confirmed at histopathologic analysis of the resected specimen after fixation in 10% formaldehyde (hematoxylin-eosin stain; original magnification, ×1).
mors and those with adenomas or borderline tumors involving the MPD are shown in Table 2.

MPD wall nodules adjacent to the nondependant wall of the MPD were observed in 17 (33%) of 51 patients with IPMN involving the MPD (Fig 3). There was moderate interobserver agreement when assessing the presence or absence of MPD nodules ($\kappa = 0.509$).

Sixteen (59%) of 27 intraductal papillary mucinous carcinomas involving the MPD had mural nodules (Table 2, Fig 3). One (4%) of the 24 patients with an intraductal papillary mucinous adenoma or borderline tumor had MPD wall nodules (Table 2, Fig 3).

Enhancement of the MPD walls.—Duct wall enhancement was observed in 25 (49%) of 51 patients with IPMN involving the MPD (Fig 4). There was good interobserver agreement in assessing enhancement of the MPD walls ($\kappa = 0.687$).

In the group of 27 patients with intraductal papillary mucinous carcinoma involving the MPD, 20 (74%) patients had duct wall enhancement, whereas in the group of 24 patients with intraductal papillary mucinous adenoma or borderline neoplasm, five (21%) patients had MPD wall enhancement (Table 2, Fig 4). The results of a subanalysis of the MPD wall enhancement in the patients with malignant tumors and adenoma or borderline tumors are reported in Table 2.

Quantitative Analysis
The median maximal diameter of the MPD was 14 mm (interquartile range, 9–26 mm; mean, 25 mm; range, 10–180 mm) (Fig 1). The median maximal diameter of the MPD of malignant IPMNs was 18 mm (interquartile range, 10–35 mm; mean, 34 mm; range, 7–180 mm).
whereas that of benign lesions was 11 mm (interquartile range, 7.3–19 mm; mean, 15 mm; range, 4–40 mm) \( (P = .038) \) (Table 2). The mean maximal diameter of the MPD wall nodules was 10.2 mm (range, 3–21 mm).

By applying univariate statistical analysis to these parameters, the presence of parietal nodules was significantly correlated with malignancy \( (P < .00001) \) (Table 2). Also, the finding of duct wall enhancement was correlated with a diagnosis of malignant IPMN \( (P = .0001) \) (Table 2). The site of dilatation was not indicative of the biologic behavior of the IPMNs \( (P = .169) \). However, patients with segmental dilatation of the MPD (head, body, or tail of the pancreas) had a lower probability of having a malignant IPMN (seven \( [33\%] \) of 21 patients) than did patients with diffuse MPD dilatations (20 \( [67\%] \) of 30 patients).

In the logistic model we developed—which considered the potential confounders of age, sex, lesion type (MPD or mixed), and site of MPD dilatation—the presence of mural nodules and/or enhancement of the duct walls (relative risk, 3.2; 95% confidence interval: 1.05, 9.78; \( P = .031 \)) were significant predictors of malignant IPMNs (relative risk, 4.48; 95% confidence interval: 1.61, 12.44; \( P = .0016 \) (Table E2 \[online\]).

Cumulative patient survival according to the type of IMPN (MPD vs mixed) is reported in Figure 5.

**Discussion**

In our study, we analyzed the predictive signs of malignancy, as determined with MR imaging and MR cholangiopancreatography, for MPD and mixed type IPMNs because their prognosis is different from that of side branch IPMNs. The risk of malignant transformation for IPMNs involving the MPD is 30%–60% \( (6,7,9,10) \), whereas it is 6%–46% \( (11–15) \) for side branch IPMNs.

In our study, the most accurate sign of malignancy was the depiction of MPD mural nodules, which were seen in 16 \( (59\%) \) of 27 patients with malignant IPMNs and in one \( (4\%) \) of 24 patients with adenomas or borderline IPMNs \( (P < .00001) \) (this lesion was detected in a borderline IPMN), with associated enhancement of the duct walls. None of the patients with intraductal papillary mucinous adenomas had mural nodules. These results are in agreement with the published findings of other studies in which researchers analyzed both MPD and side branch IPMNs together \( (3,11,13,19,22,25,26) \). The challenge for the radiologist in these cases is to identify the nodules when they are small (mean maximal diameter, 10.2 mm in our study) in order to diagnose malignant disease early in its course. This may be a difficult task, and it is most likely responsible for the moderate interobserver agreement on detection of this sign in our series. Therefore, it is important to obtain three-dimensional high-spatial-resolution images during the dynamic study. It has been shown that mural nodules may also be depicted with computed tomography (CT), particularly when two-dimensional curved reformations are obtained. These reported CT results show diagnostic accuracy is comparable with that reported with MR imaging and MR CP \( (27) \). This is important because CT is frequently the modality of choice in the assessment of patients known to have or suspected of having pancreatic disease.

According to the literature \( (11,19–21) \), contrast enhancement of the MPD walls is another sign that is predictive of malignancy; however, it is more difficult to depict than parietal nodules because it requires a point-by-point comparison between the pre- and delayed postcontrast images. However, in our series, contrast enhancement of the MPD duct walls was less reliable than the presence of parietal nodules when predicting malignant transformation because it was depicted in 20 \( (74\%) \) of 27 patients with malignant MPD or mixed type IPMNs and in five \( (21\%) \) of 24 patients with benign or borderline IPMNs. This indicates that this sign could be caused by malignant transformation and inflammatory changes, which are frequently noted in the upstream MPD in patients with IPMNs. However, the multivariate analysis performed in our study indicated that the relative risk of malignancy was increased by a margin of 4.48 when mural nodules and enhancement of the duct wall were present simultaneously.

We found that the site of the dilatation was not a significant predictor of malignancy. This result was in agreement with the findings of other published series \( (7,21) \). However, diffuse dilatation of the MPD is detected more frequently in patients with malignant IPMNs involving the MPD. This finding most likely indicates the presence of a
larger amount of neoplastic tissue; therefore, one should increase his or her level of suspicion when examining these patients.

Our results concerning the predictive value of the size of the MPD are in agreement with those of other published reports (11), indicating that malignant IPMNs had a larger median maximal diameter of the MPD (18 mm) than did benign or borderline IPMNs of the MPD (11 mm) \( P = .038 \). To assess the pancreatic duct system, Carbognin et al (28) suggested that the use of a three-dimensional MR CP sequence in conjunction with the administration of secretin was helpful in depicting the communication between side branch IPMNs and the MPD. In case of MPD IPMNs, the medical need is to characterize the lesions by depicting mural nodules. In this setting, three-dimensional MR CP, which is a respiratory-triggered pulse sequence, may be limited by some blurring due to respiratory artifacts.

In pursuing the secondary objective of our study, we found that the 5-year survival rate of patients with IPMNs involving only the MPD are not significantly different from those of patients with mixed type IPMNs \( P = .813 \). This suggests that the biologic behaviors of the two types of IPMNs are similar; therefore, patients with MPD IPMNs and those with mixed type IPMNs are candidates for surgery.

Our study had some limitations. First, the patients included in this study were taken from a select group of patients with IPMNs because they had undergone MR imaging, MR CP, and surgery; therefore, our data contain the so-called verification or work-up bias (29) that may be partially responsible for some overestimation of the frequency of the reported signs that are indicative of malignancy. For the same reason, our data are insufficient to evaluate the actual prevalence of the disease. Other limitations are the minor differences in the imaging protocol sequences and parameters, the rate of contrast agent injection, and the timing of the dynamic study (fixed time delays, automated scanning trigger software, or test bolus) due to the retrospective nature of our study.

In conclusion, our data suggest that MR imaging and MR CP may be used to identify signs, such as mural nodules along the walls of the MPD and duct wall enhancement, that are predictive of malignancy. The identification of these signs in IPMNs involving the MPD, in combination with clinical symptoms and laboratory data, should help the surgeon choose the timing and type of surgical procedure to be performed in these patients. This surgical procedure represents the only curative treatment.

Acknowledgment: We thank Dante Manfredi, MD, for his lifelong teaching and enlightening life example.

References

20. Irie H, Yoshimizu K, Aibe H, et al. Natural history of pancreatic intraductal papillary mucinous tumor of branch duct type: fol-


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International (includes Canada and Mexico)

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