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Branch-Duct Intraductal Papillary Mucinous Neoplasms: Observations in 145 Patients Who Underwent Resection

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Abstract

Background & Aims—Intraductal papillary mucinous neoplasms (IPMNs) of the pancreas arising in branch ducts are thought to be less aggressive than their main-duct counterparts, and guidelines for their conservative management were recently proposed. This study describes the combined experience of 2 tertiary centers with branch-duct IPMNs aiming to validate these recommendations.

Methods—A review of 145 patients with resected, pathologically confirmed, branch-duct IPMNs between 1990 and 2005 was conducted.

Results—Sixty-six patients (45.5%) had adenoma, 47 (32%) borderline tumors, 16 (11%) carcinoma in situ, and 16 (11%) invasive carcinoma. Median age was similar between benign and malignant subgroups (66 vs 67.5 years, respectively). Jaundice was more frequent in patients with cancer (12.5% vs 1.8%, respectively, $P = .022$) and abdominal pain in patients with benign tumors (45% vs 25%, respectively, $P = .025$). Forty percent of tumors were discovered incidentally. Findings associated with malignancy were the presence of a thick wall ($P < .001$), nodules ($P < .001$), and tumor diameter ≥ 30 mm ($P < .001$). All neoplasms with cancer were larger than 30 mm in size or had nodules or caused symptoms. After a mean follow-up of 45 months, the 5-year disease-specific survival for branch-duct IPMNs with noninvasive neoplasms was 100% and, for invasive cancer, was 63%.

Conclusions—This large cohort of resected branch-duct IPMNs shows that cancer is present in 22% of cases and validates the recent guidelines that indicate absence of malignancy in tumors < 30 mm, without symptoms or mural nodules.

A symptomatic cystic tumors of the pancreas are being identified with increasing frequency, and this has resulted in a dramatic increase in the diagnosis of intraductal papillary

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mucinous neoplasms (IPMNs) at specialized centers.¹⁻⁴ Consequently, knowledge of the clinicopathologic characteristics and natural history of specific subtypes of IPMNs has become critical. At the center of the controversy is the observation that IPMNs arising from the branch ducts seem to have a less aggressive clinical course than those arising from the main ducts. This in turn raises the question of whether branch-duct IPMN (Br-IPMNs) may be a distinct tumor type with altogether different biologic behavior than those arising in the main pancreatic duct.⁵⁻⁹ Various reports have shown significant differences in the prevalence of cancer in main-duct IPMN (including the mixed type) vs Br-IPMNs (70% vs 25%, respectively).^{1,3-5,7-13} Consequently, some authors have recommended nonsurgical management with close observation for IPMNs that arise from branch ducts and that fail to meet certain “high-risk” criteria.^{6,7,10-14} A recent consensus conference supports this view.¹² However, the majority of contemporary series has only recently begun to distinguish between main-duct IPMN and those of the side-branch variety when describing experiences managing these 2 important neoplasms.^{15,16}

We recently reported the combined experience of the Massachusetts General Hospital (MGH) and the University of Verona (UV) comprising 140 patients with resected IPMNs of the main duct and the combined type.¹³ The purpose of the current study is again to combine the experiences of these 2 pancreatic centers with resected IPMNs exclusively of the branch-duct variety to help elucidate their clinicopathologic characteristics and long-term survival and to compare these with main-duct IPMNs.

Materials and Methods

Patients

The MGH and UV institutional review boards approved this study. Patients with surgically resected, pathologically confirmed IPMNs between January 1990 and December 2005 were identified from prospectively collected databases. The absence of a stromal layer was used as criterion to distinguish Br-IPMNs from mucinous cystic neoplasms.^{12,17,18} Three hundred sixty-three patients were identified during this time period (203 MGH and 160 UV). Of these, 145 (40%) were determined to have pure Br-IPMNs, with the remaining being main-duct or combined IPMNs. Information including demographics, clinical history and presentation, diagnostic workup, type of surgical procedure, details of the pathology report, hospital course, and short- and long-term follow-up were obtained. Perioperative mortality was defined as in-hospital or 30-day death. For the analysis, Br-IPMNs with adenoma or borderline neoplasms were grouped as “benign” and Br-IPMNs with carcinoma in situ and invasive carcinoma as “malignant.”

All patients had follow-up evaluations consisting of clinical examination, serologic assessment including fasting glucose blood levels and tumoral markers, and imaging. Imaging procedures included contrast-enhanced abdominal ultrasound (US), computer tomography (CT), and magnetic resonance imaging (MRI). In most patients, recurrences were diagnosed by CT and were confirmed histologically whenever possible. Patients with benign IPMN usually had a yearly follow-up evaluation for the first 5 years and then underwent imaging evaluation in the case of abdominal symptoms. Patients with invasive carcinoma were seen every 6 months for the first 2 years and yearly thereafter.

Worsening diabetes was defined as deterioration in the metabolic control of previously diagnosed diabetes, requiring modification of the medical treatment. No specific exocrine function tests were performed. New onset of exocrine insufficiency was defined as steatorrhea and weight loss requiring pancreatic enzymes supplementation.

Statistical Analysis

Descriptive data are presented as mean $\pm$ standard deviation unless otherwise specified. Normally distributed continuous variables were compared using a 2-sample Student *t* test; the Mann–Whitney *U* test was used for nonnormally distributed variables. Categorical variables were compared using a Pearson χ^2 test and Fisher exact test when cell counts were <5 . Survival analysis was done using the Kaplan–Meier function, comparing histologic groups with the log-rank test. A *P* value of less than .05 was considered statistically significant.

Results

Of the 145 patients with resected Br-IPMNs, 66 had adenomas (45.5%), 47 borderline neoplasms (32.4%), 16 carcinoma in situ (11%), and 16 invasive carcinoma (11%). One hundred thirteen patients had benign Br-IPMNs, and 32 had malignant neoplasms.

Clinical Characteristics

Clinical characteristics are described in Table 1. There was a nonsignificant slight preponderance of females in both benign and malignant subgroups (58% vs 53%, respectively), and the median age at presentation was also similar in the 2 groups (66 vs 68 years, respectively).

Overall, 58 patients (40%) were asymptomatic, and there was no significant difference in the frequency of incidentally discovered tumors between benign and malignant (43% vs 28%, respectively, *P* = .12). Females were more likely to be symptomatic than males (68% vs 32%, respectively, *P* = .002). Differences in presentation that reached statistical significance included a higher incidence of jaundice in patients with malignant tumors and a higher incidence of abdominal pain in patients with benign tumors.

Eight patients (5.5%), 6 with adenoma and 2 with malignant IPMNs (1 carcinoma in situ and 1 invasive carcinoma), presented with synchronous or metachronous neoplasms. In 2 cases, Br-IPMNs with in situ carcinoma and adenoma were incidentally found in the surgical specimen after resection for ductal adenocarcinoma and ampullary carcinoma, respectively. Three patients with branch-duct adenoma were unexpectedly found to have a secondary tumor (1 neuroendocrine microadenoma, 1 mucinous cystadenoma, and 1 small bowel lymphoma), and another patient with Br-IPMNs with invasive carcinoma had a neuroendocrine microadenoma. Two patients with Br-IPMNs adenoma developed metachronous squamous cell carcinoma of the lung.

Tumor Location and Size

The anatomic locations are described in Table 2. Two thirds of Br-IPMNs were located in the head or uncinate process of the pancreas. The mean diameter of the lesions, as determined by preoperative radiologic studies, was 30.6 ± 15.7 mm (median, 30; range, 10–90 mm), and multifocality was described in 21 patients (14.5%). There was no significant difference in the incidence of malignancy when comparing the location of benign and malignant neoplasms.

Surgical Resections

Surgical resections comprised 97 (67%) pancreati-coduodenectomies (with pylorus preservation in 28 cases), 29 (20%) distal pancreatectomies (14 with splenic preservation), 15 (10%) middle pancreatectomies, and 2 (1.4%) total pancreatectomies. One patient (0.7%), in the early period of the series, underwent enucleation and another (0.7%) underwent a combined pancreaticoduodenectomy and distal pancreatectomy because of the

presence of a multifocal lesion in the head and tail. The number of resections has increased over time, notwithstanding that more selective criteria for resection have been applied over the last years (Figure 1A). This policy has resulted in a notable decrease in the number of resections for incidentally discovered lesions (Figure 1B). At present, both of our institutions subscribe to the recommendations of the consensus conference of Sendai.¹²

Pathology

The diagnosis of Br-IPMN relies on the presence of 1 or more cystic neoplastic lesions communicating with the main pancreatic duct (but not involving it) and lacking an ovarian-like stromal layer.^{12,17,18} The pathologic features of the tumors are described in Table 3. The mean diameter (as measured by the pathologist) was 26.4 ± 16.8 mm (median, 20; range, 5–100 mm), with a statistically significant difference between benign and malignant (mean, 23.8 vs 40 mm, respectively, $P = .003$; median, 20 [range, 5–50 mm] vs 30 [range, 8–100 mm], respectively, $P = .003$). Pathologic examination revealed the presence of a higher frequency of multifocality compared with the radiologic assessment (25.6% vs 14.5%, respectively, $P = .028$). Moreover, there was a statistically significant difference in tumor size between radiologic and pathologic examination (mean radiologic size, 30.6 ± 15.7 mm vs mean pathologic size, 26.4 ± 16.8 mm, $P = .01$ [median radiologic size, 30 mm vs median pathologic size, 20 mm, $P = .001$]).

Significant factors associated with malignancy were the presence of a thick wall ($P < .001$), nodules ($P < .001$), and tumor diameter equal to or greater than 30 mm ($P < .001$). The likelihood of malignancy increased significantly with the presence of nodules. Nodules were absent in all 66 cases of adenoma, whereas they were identified in 4 of 47 borderline tumors (8.5%), 7 of 16 in situ carcinomas (43.8%), and 12 of 16 invasive carcinomas (75%). The pathologist described thick walls only in invasive carcinomas ($n = 4$ cases). Multifocality and septae were not significantly different between benign and malignant subgroups. Figure 2 is a scatter plot of radiologic tumor size as a function of histologic subtype and presence or absence of symptoms and nodules.

Of the 16 patients with invasive carcinoma, 19% had positive lymph nodes. The mean number of nodes resected in these patients was 20, and the mean number of positive nodes was 4. Vascular invasion was present in 1 (6%) and neural invasion was present in 3 (19%) patients. The mean tumor size of Br-IPMN with invasive cancer was 50 ± 24 mm. Only 3 patients with invasive carcinoma had carcinoma with a diameter of ≥ 30 mm, and 2 out of 3 patients had only small foci of invasive carcinoma in the context of adenoma or borderline tumors. These 3 patients had also nodules or symptoms present.

Data on pancreatic transection margins were unavailable in 7 patients (5 affected by adenoma, 1 by borderline neoplasm, and 1 by in situ carcinoma). In 133 (96.4%) patients, the transection margin was negative (the presence of mucinous metaplasia was considered as a negative margin). Of the remaining patients, 4 had adenoma and 1 had borderline dysplasia in the side branches of the transection margin (by definition, the main pancreatic duct was without any atypia). No patient with a positive transection margin developed a neoplastic recurrence.

Perioperative Course

Table 4 shows perioperative complications. Thirty-nine patients (27%) developed abdominal complications, the most common of which was pancreatic fistula, occurring in 17% of cases. Forty-seven patients (32.4%) had extra-abdominal complications. The median postoperative length of stay was 9 days (range, 4–77; mean, 12 ± 10 days). Seven patients (4.8%) required

readmission for perioperative complications. There were no operative deaths and no surgical reexplorations.

Long-Term Follow-Up, Recurrence, and Survival

Follow-up was available in 98% of patients, and the mean duration of follow-up was 45.9 ± 34.2 months (median, 38.7; range, 1–180 months). Ten patients had tumor recurrence (6.9%). Four patients had only local recurrence, and they all had an IPMA with a negative pancreatic transection margin. These recurrent (or meta-chronous) lesions were asymptomatic and discovered after a mean follow-up of 34.7 months. In all cases, they were small in size (<30 mm), without nodules or thick walls, and are being managed conservatively with close clinicoradiologic observation. Six of the 16 patients (38%) with invasive carcinoma developed metastases. Three patients developed both local and distant recurrence, whereas the other 3 had only distant recurrence. All cases of distant recurrences were initially manifested by liver or lung involvement, a mean of 26.6 months (range, 6–72 months) after the initial resection. Of these 6 patients, 2 had positive lymph nodes in the initial resection, and 4 did not. All 6 patients died as a consequence of tumor recurrence within 24 months (mean, 12.6 months; range, 6–24 months) after the distant metastases were diagnosed.

Overall, 5- and 10-year actuarial survival for the entire cohort was 95% and 70%, respectively (Figure 3A). The 5-year, disease-specific survival for patients with Br-IPMN adenoma, borderline, or carcinoma in situ was 100%, and that for the 16 patients with invasive carcinoma was 63% (Figure 3B).

Thirty-two patients (22%) developed new onset of exocrine insufficiency; of these, 25 had a benign Br-IPMN (22%), and 7 had a malignant Br-IPMN (22%). Forty-one patients (28%) developed new onset ($n = 28$, 19%) or worsening ($n = 13$, 9%) diabetes. Of these 41 patients, 32 had benign disease (28%) (new onset of diabetes, 23 patients [20%]; worsening diabetes, 9 patients [8%]).

Discussion

The emergence of IPMN as a distinct diagnostic entity has transformed the management of pancreatic cystic lesions over the last 15 years. Patients presenting with symptoms of acute or chronic pancreatitis, jaundice, and abdominal pain or with pancreatic abnormalities detected incidentally by CT, MRI, or ultrasound all currently include IPMN within the differential diagnosis. Our ability to identify IPMN correctly has gradually increased,^{19,20} and there has been increasing recognition that there are 2 distinct subtypes: neoplasms that involve primarily the main pancreatic duct (with or without extension to the side branches) and IPMN affecting only the branch ducts. Pioneer work by Kobari et al²¹ and Terris et al²² suggested that Br-IPMNs were not only topographically different but exhibited a less aggressive clinical behavior and pathologic phenotype. These observations, confirmed by others,^{23,24} led to reports of small series of patients for whom no treatment was offered other than observation alone.^{6,12,25} The apparent success of this strategy was used by a study group that met in 2004 in Sendai, Japan, and published consensus guidelines for the management of IPMNs and mucinous cystic neoplasms.¹² Their guidelines suggest that Br-IPMNs that cause no symptoms, measure less than 3 cm in diameter, and have no nodules can be observed with periodic imaging in contrast to main-duct IPMNs in which resection is always warranted. These recommendations have been widely accepted by us and others, and, in fact, a recent publication describes the experience of the University of Verona with asymptomatic Br-IPMN managed expectantly and shows that, in a cohort of 89 patients followed for a median of 32 months, only 5 (5.6%) showed progression and required surgery, and none of those patients had cancer at the time of resection.²⁵

In the last few years, the number of resections for Br-IPMN has progressively increased, probably because these neoplasms are being diagnosed more frequently (Figure 1A). However, the gradual application of more selective criteria for resection^{6,12,25} and application of the International Association of Pancreatology guidelines have resulted in a marked decrease in the number of resections in asymptomatic patients (Figure 1B).

The present series, combining the experience of the MGH and the UV, is to date the largest cohort of patients with resected Br-IPMN. It shows that this entity spans a wide range of histopathologic atypia, from adenomas to invasive adenocarcinomas with metastasis to lymph nodes, liver, and lung. This spectrum is similar to what we and others have observed in main duct IPMNs,^{3,4,13} but the proportion of lesions without dysplasia (ie, adenomas) is almost 4 times greater in Br-IPMN (46% vs 12%, respectively) and the likelihood of invasive carcinoma proportionally less (11% in Br-IPMN vs 42% in main-duct IPMN). Because our series spans 15 years and over time our resection policy has changed to a more conservative one in which most patients with small, incidentally discovered Br-IPMNs are being observed, it is very likely that the true ratio of benign-to-malignant lesions in Br-IPMN is even greater. A similar conservative policy has never been in place with main-duct IPMN (all good surgical candidates with this diagnosis are offered resection at our institutions), and therefore these differences are likely to be real.

In this study, for the purpose of the analysis, we grouped together patients with adenoma and borderline neoplasms and patients with carcinoma in situ and invasive carcinoma. However, when analyzing the disease-specific survival, we decided to group patients with Br-IPMNs with carcinoma in situ together with those with adenoma and borderline neoplasms because no patient with carcinoma in situ developed metastases or died of disease.

The median age of presentation in this series was 67 years, which is similar to that found by us in main-duct IPMN (64.8 years),¹³ but, unlike the latter, wherein a significant difference in age was found between patients with benign and malignant neoplasms (60.9 years vs 67.3 years, respectively), there was no such difference found in Br-IPMN. Although our findings may reflect a type II error, given the small number of in situ and invasive cancers, they could also indicate either that not all Br-IPMN adenomas progress to malignant disease, as has been suggested by some series in which asymptomatic patients are being followed,^{10,12,25} or do so very slowly.

From the clinical standpoint, the most common presenting symptom was abdominal pain, followed by weight loss and pancreatitis. The latter occurred in 15% of patients with Br-IPMN, but many of the patients presenting with pancreatitis went undiagnosed for long periods of time because the cyst was thought to be the consequence of the pancreatitis and not its cause. It is noteworthy that 58 patients (40%) in this series were asymptomatic, the diagnosis being made incidentally because of imaging performed for other reasons. Although 28 of these patients under our current policy would not have undergone resection, the remaining 30 had tumors greater than 3 cm in size or had nodules. In fact, 9 of these 30 (30%) patients had either carcinoma in situ or invasive cancer on final pathologic exam. This underscores the importance of not dismissing incidentally discovered pancreatic cysts as benign.

Several factors were found to be significantly associated with malignancy in Br-IPMN. The only clinical one was the presence of jaundice, which was present in only 12.5% of the patients with malignant disease. Although diabetes has been found to be associated with malignancy in main-duct IPMNs, we found no significant differences in the frequency of diabetes when comparing patients with benign and malignant Br-IPMN.

From the pathologic standpoint, larger size of the tumor, nodularity, and thick septae were all strongly associated with malignancy. The step-up in likelihood of malignancy when nodules were seen was particularly striking. None of the 66 patients with Br-IPMN adenomas had nodules, but these were present in 8.5% of borderline tumors, in 44% of Br-IPMNs with carcinoma in situ, and in 75% of invasive carcinomas.

It is reassuring that this large cohort of resected Br-IPMNs confirms the observations that led to the Sendai Consensus guidelines¹² since no patient in this series had carcinoma in absence of symptoms unless the lesion was greater than 3 cm in diameter by a radiologic point of view or had nodules within it. Of the 28 patients who would not have undergone resection under this new policy, 21 had adenomas and 7 borderline neoplasms. If we exclude these patients, the frequency of carcinoma would have been 28%, that of borderline tumors 34%, and the remaining 38% adenomas. Considering the radiologic size, if the threshold for resection were <4 cm (instead of 3 cm), 2 other patients would have avoided resection, and both were proven to have borderline neoplasms. Increasing the size threshold further to 4 cm would have spared surgery to 5 other patients but would have been less safe because 1 asymptomatic patient with a 4-cm lesion had carcinoma in situ.

Two thirds of the neoplasms were located in the head and uncinate process of the pancreas, and 14.5% were multifocal. Neither location nor multifocality correlated with malignancy. We were able to compare cyst size assessed by the pathologist with that measured during cross-sectional imaging and found that radiologic measurements are consistently approximately 15% greater. This is important to keep in mind because most of the data that were used to derive risk of malignancy originated in analysis of resected specimens, and it is not always specified whether the measurement was obtained from the preoperative imaging or by the pathologist. Inasmuch as decision making regarding observation vs resection relies on radiologic size, it is reasonable to assume that this overestimation relative to the “true” size of the pathologic specimen makes the criteria for observation safer. The pathologist also detected multifocality in the specimen with a higher frequency than the radiologist (26% vs 14.5%, respectively).

We recommend that all patients with resected Br-IPMNs be followed in a surveillance program to detect recurrent disease. This policy should be applied, as suggested by the IAP guidelines, not only to patients with invasive carcinoma but also to patients with noninvasive Br-IPMNs because patients with noninvasive neoplasms may develop recurrence because of metachronous multifocal tumors or because of positive transection margins, and, in these cases, further resection can be attempted. Patients with invasive tumors do have a significant risk of recurrence and should be carefully evaluated every 6 months. It is unclear whether there is a role for surgery of isolated local or distant metastasis in IPMN. Unfortunately, in the present series, all patients with invasive cancer who had recurrence developed widespread metastatic disease and died of disease soon thereafter.

Although the median follow-up of 46 months in this series is relatively short and the number of patients with invasive carcinoma small,¹⁶ the calculated actuarial 5-year survival for patients with invasive cancer was 63%, which is similar to what we found in main-duct IPMN,¹³ and much higher than expected in ductal adenocarcinoma of the pancreas. Our results also show perfect survival following resection of Br-IPMN adenoma, borderline, and carcinoma in situ. It is certainly possible that, as this series matures, more patients will develop recurrence, and some will require further operations.

Finally, this series also demonstrates that resection for Br-IPMNs, when done in high-volume centers, can be accomplished safely. Although abdominal complications occurred in

27% of patients and overall morbidity was greater than 50%, surgical-related mortality was nil and the median hospital stay 9 days.

In summary, the analysis of this large series of resected Br-IPMN shows that this variant, although it exhibits a lesser frequency of dysplastic changes and cancer than its main-duct counterpart, nonetheless can evolve to invasive and metastatic cancer. Although resection of these lesions can be accomplished safely and has excellent long-term outcomes, we confirm that the guidelines set forth by the Sendai Consensus¹² accurately and effectively exclude malignancy and thereby allow for safe nonoperative observation of selected patients who are asymptomatic.

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Abbreviations used in this paper

Br-IPMN	branch-duct intraductal papillary mucinous neoplasm
CT	computerized tomography
IPMA	intraductal papillary mucinous adenoma
IPMN	intraductal papillary mucinous neoplasm
MGH	Massachusetts General Hospital
MRI	magnetic resonance imaging
US	ultrasound
UV	University of Verona

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Figure 1.

(A) Distribution of overall number of pancreatic resections by year for branch-duct IPMNs (n =145). (B) Symptomatic vs incidentally discovered pancreatic resections for branch-duct IPMNs (2002–2005).

Figure 3.

(A) Overall 5- and 10-year survival for the entire series were 95% and 70%, respectively.

(B) The 5-year disease-specific survival was 100% for patients affected by adenoma, borderline, or carcinoma in situ and 63% for the 16 patients with invasive carcinoma.

Table 1

Clinical Characteristics of 145 Patients With Branch-Duct IPMN

	Benign (n = 113)	Malignant (n = 32)	Total (n = 145)	P value (benign vs malignant)
Male, n (%)	47 (41.6)	15 (46.9)	62 (42.8)	NS
Female, n (%)	66 (58.4)	17 (53.1)	83 (57.2)	NS
Median age, yr (range)	66 (39–90)	67.5 (35–84)	67 (35–90)	NS
History of smoking, n (%)	44 (38.9)	8 (25)	52 (35.9)	NS
Previous diagnosis of chronic pancreatitis, n (%)	13 (11.5)	4 (12.5)	17 (11.7)	NS
Symptoms, n (%)	64 (56.6)	23 (71.9)	87 (60)	NS
Median duration of symptoms in weeks (range)	19 (2–520)	18 (4–572)	18 (4–572)	NS
Abdominal pain, n (%)	52 (46)	8 (25)	60 (41.4)	.025
Jaundice, n (%)	2 (1.8)	4 (12.5)	6 (4.1)	.022
Weight loss, n (%) ^a	28 (24.8)	7 (21.9)	35 (24.1)	NS
Acute pancreatitis, n (%)	17 (15)	5 (15.6)	22 (15.2)	NS
Deterioration of diabetes, n (%)	9 (8)	4 (12.5)	13 (9)	NS
Asymptomatic, n (%)	49 (43.4)	9 (28.1)	58 (40)	NS
Median cancer antigen 19–9, U/L, range	10 (1–156)	10 (1–1774)	10 (1–1774)	NS
Other tumor (synchronous or metachronous)	6 (5.3)	2 (6.3)	8 (5.5)	NS

^aLoss of >5% of body weight.

Table 2

Location Of The Tumor According To Preoperative Radiologic Studies

	Benign (n = 113)	Malignant (n = 32)	Total (n = 145)	P value (benign vs malignant)
Head, n (%)	44 (38.9)	17 (53.1)	61 (42.1)	NS
Uncinate process, n (%)	17 (15)	5 (15.6)	22 (15.2)	NS
Body, n (%)	24 (21.2)	3 (9.4)	27 (18.6)	NS
Tail, n (%)	10 (8.8)	4 (12.5)	14 (9.7)	NS
Multifocal, n (%)	18 (15.9)	3 (9.4)	21 (14.5)	NS
Mean radiologic size (mm) ^a	27.9 (10–84)	40.5 (10–90)	30.5 (10–90)	.0001

NOTE. Radiologic studies include abdominal US, CT, MRI, magnetic resonance cholangiopancreatography.

^aRadiologic size was available in 120 patients (benign, 94; malignant, 26).

Table 3

Pathological Characteristics of 145 Branch-Duct IPMN

	Benign (n = 113)	Malignant (n = 32)	Total (n = 145)	P value (benign vs malignant)
Size <30 mm, n (%) ^a	86 (77.5)	12 (41.4)	98 (70)	.0001
Presence of thick wall, n (%) ^b	0	4 (12.5)	4 (2.8)	.0001
Presence of nodules/papillae, n (%)	4 (3.5)	19 (59.4)	23 (15.9)	.0001
Presence of septae, n (%)	17 (15)	3 (9.4)	20 (13.8)	NS
Multifocal lesions, n (%)	28 (24.8)	9 (28.1)	37 (25.5)	NS
Unifocal lesions, n (%)	85 (75.2)	23 (71.9)	108 (74.5)	NS
Mean size (mm) ^a	23.8 (5–50)	40 (8–100)	26.4 (5–100)	.003

^aPathologic size was available in 140 patients (benign, 110; malignant, 30).

^bThick wall was defined as a cyst wall with a thickness greater than 3 mm.²⁶

Table 4

Perioperative Results in 145 Patients Undergoing Pancreatic Resection for Branch-Duct IPMNs

Perioperative Complications	No. (%)
Overall morbidity	74 (51)
Abdominal complications ^a	39 (27)
Pancreatic fistula	25 (17)
Biliary fistula	4 (2.8)
Delayed gastric emptying	9 (6)
Intrabdominal collections/abscess	13 (9)
Nonsurgical complications ^b	45 (31)
Perioperative Readmission	7 (4.8)
Reoperation	0 (0)
Mortality	0 (0)

^a Abdominal complication is defined as the occurrence of pancreatic or biliary fistula, abscess, collection, hemorrhage, wound infection, and delayed gastric emptying.

^b Nonsurgical complications is defined as the occurrence of cardiopulmonary, neurologic, urologic, and septic complications.