

# Is Preoperative Angiography Useful in Patients with Periapillary Tumors?

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Ninety patients with periampullary tumors, staged by CT scan and believed to be resectable, were staged further by visceral angiography. Most of these patients (78) had carcinoma of the head of the pancreas. Visceral angiography was normal in 62 patients. Major vessel encasement (17 patients) or occlusion (11 patients) was identified in 28 patients. There were no complications related to angiography. Among the 62 patients with normal angiograms, 48 underwent a pancreaticoduodenectomy, for a resectability rate of 77%. Among the 17 patients with vessel encasement, the resectability rate was 35%. For the 11 patients with vessel occlusion, the resectability rate was 0%. Combined with CT scan, visceral angiography is a useful adjunct in the staging of patients with periampullary tumors. Major vessel occlusion precludes resection, and major vessel encasement makes resection unlikely. If visceral angiography is normal, it is very likely that the tumor will be resectable.

SINCE ITS INTRODUCTION by Whipple et al.<sup>1</sup> in 1935, pancreaticoduodenectomy has been the most effective treatment for periampullary carcinomas. In recent years a marked drop in both postoperative morbidity and mortality rates, as well as improved survival, have been reported for this operative procedure.<sup>2-4</sup> This has resulted in the performance of many more pancreaticoduodenectomies. However, at the time of laparotomy, many patients with periampullary carcinomas are found not to be resectable. Nonoperative techniques for the management of obstructive jaundice secondary to a periampullary tumor have likewise improved and may, in many instances, provide adequate palliation for unresectable patients.<sup>5,6</sup> These parallel improvements in both operative and nonoperative management make appropriate staging more important than it was a decade ago when laparotomy was still required in all patients to establish the diagnosis and provide palliation. Currently

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computerized tomographic (CT) scanning is the most commonly used diagnostic tool for periampullary tumors and is also used for staging.<sup>7</sup> Even with CT staging, many patients at laparotomy prove not to be resectable.

Angiography was used as a diagnostic tool in the evaluation of patients with jaundice and periampullary tumors in the 1960s and 1970s.<sup>8-12</sup> Many studies from this era demonstrated its limited role in establishing the diagnosis of malignancy. Clearly CT scan has surpassed angiography in predicting the diagnosis of malignancy. However, because of the ability of visceral angiography to identify major vascular involvement by local tumor extension, it still may have a role in staging patients with periampullary neoplasms. In a group of patients with obstructive jaundice and periampullary masses referred for surgical evaluation at The Johns Hopkins Hospital, the efficacy of angiography was evaluated, not as a diagnostic tool, but as a further means of staging after CT scan in an effort to avoid laparotomy in patients who clearly are not resectable.

## *Clinical Material*

During a 3-year period, beginning January 1, 1987, 90 patients with obstructive jaundice secondary to periampullary tumors underwent visceral angiography. All patients had previously undergone a diagnostic CT scan and most had had either percutaneous transhepatic or endoscopic retrograde cholangiography. Many had undergone upper gastrointestinal endoscopy and barium studies. Fourteen had undergone magnetic resonance imaging (MRI). Angiography was performed as the final staging test in those patients who were believed to be resectable on the basis of their previous studies. Of the 90 patients,

Presented at the 101st Annual Meeting of the Southern Surgical Association, Hot Springs, Virginia, December 3-6, 1989.

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Accepted for publication December 28, 1989.

51 were men and 39 were women. The mean age was 60 years, and ranged from 21 to 86 years. All 90 patients eventually had the diagnosis of malignancy confirmed histologically. The majority of patients had adenocarcinoma of the head of the pancreas (Table 1).

### Visceral Angiography

Using aseptic technique and 1% lidocaine as a local anesthetic, the common femoral artery was punctured percutaneously using a modified Seldinger technique. Conventional cut film visceral angiography was then performed. When cut film angiography failed to provide sufficient diagnostic information, intra-arterial digital subtraction angiography (DSA) was performed. A 5 french Simmons I catheter and a 0.035-inch floppy-tipped guide wire were used in the majority of patients to selectively catheterize the celiac axis and the superior mesenteric artery (SMA). When the celiac axis or SMA could not be selectively catheterized, a lateral DSA abdominal aortogram was performed to screen for possible occlusion or severe stenosis secondary to encasement or atherosclerosis. Infrequently a selective common hepatic or splenic arteriogram was performed to help evaluate the arterial or venous anatomy. Arteriography was performed in the anterior/posterior projection. Oblique projections were infrequently used. Injection rates for the standard selective cut film celiac and SMA arteriograms generally ranged from 7 to 9 mL/second for a total volume of 50 to 70 mL of ionic contrast (usually 76% iodinated contrast). To better visualize the superior mesentery vein (SMV) and portal vein, 25 mg of Priscoline (Ciba Pharmaceutical Co., Summit, NJ) was injected through the catheter directly into the SMA just before filming.

All angiograms were examined for evidence of arterial or venous encasement or occlusion that might preclude resection. Encasement or occlusion of vessels normally removed during a pancreaticoduodenectomy (such as the gastroduodenal artery) was not considered a positive finding. In addition anatomic variants that would be helpful for the surgeon to know before pancreaticoduodenectomy were recorded.

TABLE 1. Ninety Patients Undergoing Visceral Angiography

Diagnosis	Number
Carcinoma of the head of the pancreas	78
Carcinoma of the distal bile duct	3
Carcinoma of the ampulla	2
Carcinoma of the duodenum	1
Other	
Cystadenocarcinoma	3
Hamoudi tumor	1
Lymphoma	1
Metastatic tumor	1

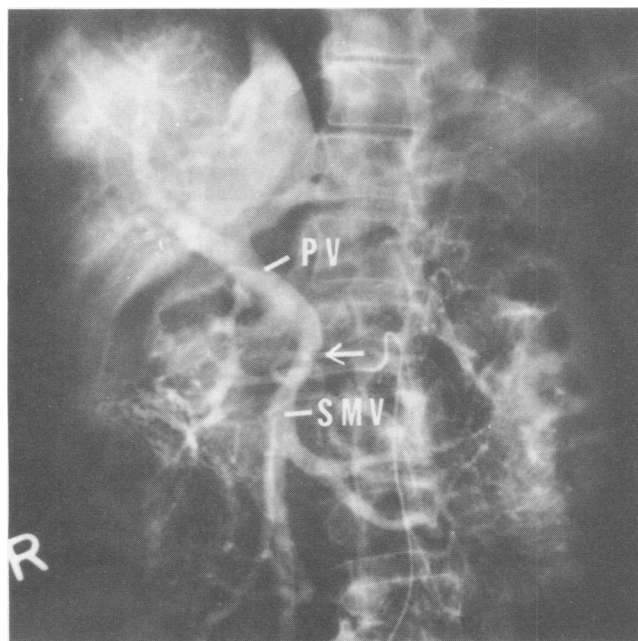


FIG. 1. The venous phase of this injection of the SMA demonstrates a long segment of SMV narrowing, identified by the arrow. This was secondary to tumor encasement. The finding was confirmed at laparotomy and the patient was unresectable.

Sixty-two patients had no evidence of major vessel encasement or occlusion, and therefore had no angiographic findings that would suggest that their tumors were not locally resectable. The remaining 28 patients had angiographic findings suggesting vessel encasement or occlusion. Encasement was seen more frequently than occlusion, and venous involvement was more common than arterial. Venous encasement was demonstrated involving the portal vein in 15 patients, the SMV in 11 patients, and the splenic vein in 1 patient (Fig. 1). Arterial encasement was identified involving the SMA in 4 patients, the celiac axis in 1 patient, and the hepatic artery in 3 patients. Venous occlusion of the portal vein was demonstrated in 7 patients, of the SMV in 4 patients, and of the splenic vein in 2 patients (Fig. 2). Arterial occlusion of the SMA was seen in 2 patients. In many instances patients with positive visceral angiograms had more than one vessel involved (Table 2). Nine patients had a replaced right or left hepatic artery arising from the SMA. Many other anatomic variants, including the left hepatic artery arising from the left gastric artery, were identified. However only the hepatic arterial branches arising from the SMA were believed to represent important anatomic information for the surgeon before performing a pancreaticoduodenectomy.

### Clinical Course

There were no complications attributable to angiography in these 90 patients. Specifically there were no in-

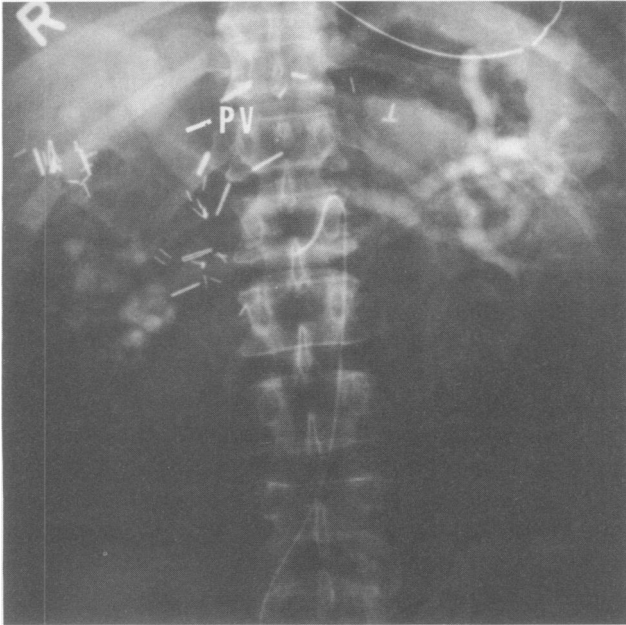


FIG. 2. The venous phase of this celiac axis injection demonstrates that the splenic vein is drained by collaterals and therefore occluded. The SMV was not visualized after SMA injection and was believed to be occluded. These findings were documented at laparotomy. The patient was unresectable.

stances of major bleeding from the angiographic puncture site, embolic events related to angiography, or pseudoaneurysms at the angiographic puncture site. There were no instances of intimal injury. No patient developed renal failure after angiography.

Among the 62 patients in whom angiography demonstrated no evidence of major vascular encasement or occlusion, 48 were found to be resectable at the time of laparotomy and underwent a pancreaticoduodenectomy (77%). Of the 14 patients found to be unresectable, seven had liver metastasis. Three other patients were found to have peritoneal implants at the time of laparotomy. In three patients the tumor invaded the root of the transverse mesocolon with SMA involvement. The angiograms in these three patients had been interpreted as normal for a false-negative rate of 5%. The final patient was found at laparotomy to have a lymphoma involving the pancreas and therefore was not a candidate for pancreaticoduodenectomy.

In 28 patients visceral angiographic findings of vessel encasement or occlusion suggested that the periampullary tumor was not resectable. However, at the time of laparotomy, six of these patients were found to be resectable and underwent pancreaticoduodenectomy (21%). Two of these six patients were documented by angiography to have portal vein encasement. The encasement was confirmed at surgery but was resected as an extension of pancreaticoduodenectomy and the portal vein was recon-

structed. Two other patients had false-positive readings of encasement at the SMV portal venous junction and were resectable at the time of exploration (Fig. 3). With angiography the final two patients were believed to have SMA encasement, but laparotomy proved this untrue and they underwent pancreaticoduodenectomy. There was no evidence, on reviewing the angiograms, to suggest that catheter-induced spasm in the SMA accounted for this false-positive finding, but that is the most feasible explanation. Therefore four patients had falsely positive angiograms, for a false-positive rate of 14%. None of the patients with arterial or venous occlusion were found to be resectable at exploration. Thirteen of the twenty-eight patients had angiographic findings that were so convincing that the patients were not explored and nonoperative palliation was carried out. Seven of these thirteen nonexplored patients had vessel occlusion and, as previously mentioned, no patients explored with vessel occlusion were found to be resectable. Two additional patients had liver metastasis confirmed by the combination of angiography and CT. In both cases the standard CT scan had been inconclusive for metastasis. The remaining four patients had multiple arterial and venous encasements that were so widespread that nonoperative management was chosen.

Thus among the entire group of 90 patients staged by CT scan, 54 underwent pancreaticoduodenectomy, for a resectability rate of 60%. After further staging by visceral angiography, 48 of 62 patients were found to be resectable, for a resectability rate of 77%. However 6 of 28 patients, or 21%, who were not believed to be resectable on the basis of visceral angiography were, in fact, resectable at the time of laparotomy.

If one only considers the 78 patients with adenocarcinoma of the head of the pancreas believed to be resectable

TABLE 2. *Visceral Angiography in 90 Patients*

Findings	Patients
No vessel encasement or occlusion	62
Vessel encasement or occlusion	28
Encasement*	
Portal vein	15
Superior mesenteric vein	11
Splenic vein	1
Superior mesenteric artery	4
Celiac axis	1
Hepatic artery	3
Occlusion*	
Portal vein	7
Superior mesenteric vein	4
Splenic vein	2
Superior mesenteric artery	2
Celiac axis	0
Hepatic artery	0
Variant arterial anatomy*	9

\* Several patients had more than one finding.

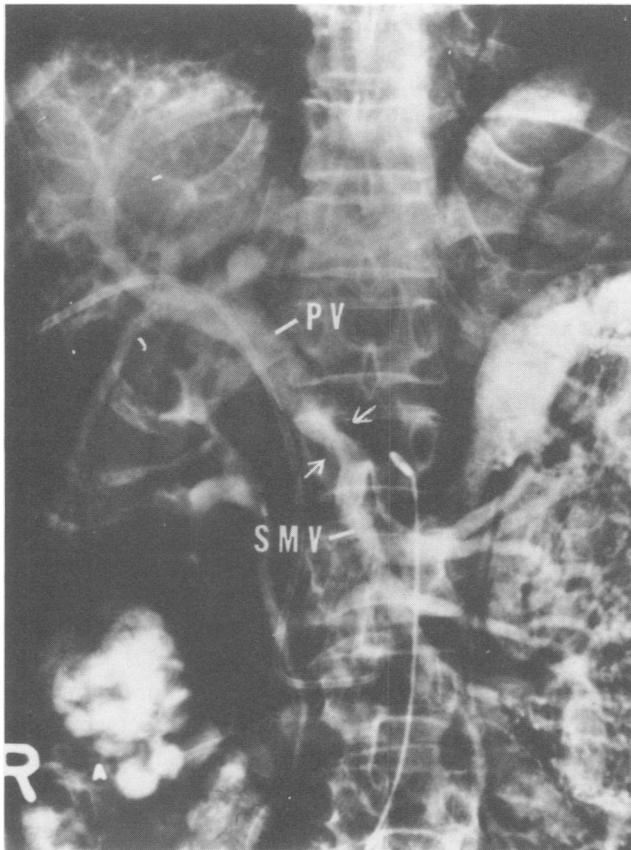


FIG. 3. The venous phase of this SMA injection demonstrates notching on the right wall of the portal vein-SMV junction. This is a normal variant. The defect in the portal vein-SMV junction (arrow) is secondary to the in flow of noncontrast media containing splenic venous blood. These phenomena can account for false-positive venograms in the evaluation of periampullary neoplasms.

on the basis of CT scan, 44 were found to be removable, for a resectability rate of 56%. After staging by visceral angiography, 53 were believed to be resectable, and at the time of laparotomy, 39 of these underwent a pancreaticoduodenectomy. Thus the resectability rate was increased to 74%. However, on the basis of visceral angiography, 25 patients with adenocarcinoma of the head of the pancreas were believed not to be resectable, but at the time of laparotomy five tumors were found to be removable (20%).

There were two deaths among the 54 patients who underwent pancreaticoduodenectomy, for a hospital mortality rate of 3.7%. There was one hospital death in the group of 36 patients who did not undergo pancreaticoduodenectomy, for a hospital mortality rate of 2.8%. This one death was in the group of 23 patients who were explored but not resected. There were no deaths in the group of 13 patients managed without operation.

## Discussion

In the 1960s the diagnosis of a periampullary malignancy before surgery in a patient presenting with obstructive jaundice was difficult. Direct imaging of this area by CT scan, ultrasound, or MRI was not available. The usefulness of indirect imaging of the periampullary region by upper gastrointestinal series was limited. Retrograde endoscopic cholangiopancreatography had not been introduced and percutaneous transhepatic cholangiography was only infrequently performed.<sup>13</sup> In this climate visceral angiography was evaluated as a means of diagnosing these tumors in patients presenting with obstructive jaundice. When a tumor blush or tumor vessels were identified, or major vascular encasement or occlusion was seen, this was interpreted as indirect evidence of a periampullary malignancy.<sup>8,9</sup> Unfortunately these positive findings were seen in only a small proportion of patients with periampullary neoplasms and thus visceral angiography was abandoned in the work-up of such patients. During the same period, virtually all patients with periampullary tumors required surgery. Surgery was needed not only for diagnosis but also to provide the only means of palliation. Today this situation also has changed. When a patient presents with obstructive jaundice, a CT scan, ultrasound, or MRI can identify with a high degree of accuracy the lesion.<sup>14</sup> The site of tumor origin can be localized further by percutaneous or endoscopic retrograde cholangiography. Finally histologic confirmation can be obtained by fine-needle aspiration in most patients. Thus surgery is no longer needed for definitive diagnosis. Furthermore we believe that surgery is no longer the only option for palliation in those patients who are unresectable. Jaundice can be effectively managed by internal drainage with a catheter inserted percutaneously or by an endoprosthesis inserted percutaneously or endoscopically.<sup>5,6</sup> Because most patients do not develop duodenal obstruction, gastrojejunostomy can be performed only in those who subsequently (usually months later) develop duodenal obstruction. Some have questioned whether this approach provides as effective palliation as biliary-enteric bypass and gastrojejunostomy performed surgically. A prospective randomized study is in progress to evaluate the relative efficacy of these two approaches. An interim report demonstrates no initial deaths related to endoprosthesis insertion compared to a 10% perioperative mortality rate related to surgical palliation. At the end of 1 month there is a significant survival advantage in the endoprosthesis group but, at 6 months, the surgical group appears to have slightly better palliation.<sup>15</sup> Thus the issue has not been resolved entirely.

If one accepts the thesis that nonoperative palliation is an attractive alternative to surgical palliation in an indi-

vidual with an unresectable periampullary neoplasm, then preoperative staging becomes important. The CT scan today is the most commonly used staging tool for patients with periampullary tumors. Liver metastases of 1 cm or more in diameter can be detected with a high degree of accuracy. Regional lymphadenopathy can be identified and vessel occlusion or encasement can occasionally be determined. Using CT as the staging tool, 90 patients in the current series had a resectability rate of 60%. If one considers only the 78 patients with carcinoma of the head of the pancreas, the resectability rate was 56%. These figures compare favorably to a decade ago, before CT staging, when resectability rates were in the range of 10% to 20% for pancreatic cancer. When visceral angiography was added to CT scanning as a means of preoperative staging, the resectability rate for pancreatic cancer increased to 74%. In addition to providing further information on staging, visceral angiography also delineates variant anatomy that can be valuable to the surgeon performing a pancreaticoduodenectomy. Both the right and left hepatic arteries can arise from the superior mesenteric artery, instead of the common hepatic artery off the celiac axis. These anomalies were seen in 9 of our 90 patients (10%). When these vessels arise from the superior mesenteric artery, they usually course directly posterior to, but occasionally in, the uncinate process of the pancreas. If the surgeon is unaware of their presence, they can be ligated during a pancreaticoduodenectomy and liver necrosis and/or liver abscess formation may follow, especially in patients with obstructive jaundice. This sequence lead to death in a patient operated on several years ago in this hospital.

Visceral angiography is not without risk. Bleeding at the femoral artery puncture site or subsequent pseudoaneurysm formation can both occur, as can intimal injury anywhere along the catheterized arterial system. A sizable contrast media load is delivered and renal injury can result. However interventional radiologists have become so skilled and pretest hydration so routine that these complications are very uncommon. In our series of 90 patients, there were none. An additional risk is that of a false-positive exam, thus excluding someone from laparotomy who might otherwise be resectable. Two patients in the present series whose angiograms were interpreted as showing SMA encasement were found to be resectable. Arterial spasm secondary to catheter injury may have been responsible for this error. Two additional patients were suspected of having venous encasement at the junction of the portal vein and SMV. At the time of surgery, no encasement was present and both were resectable. Notching of the right lateral wall of the portal vein-SMV junction, which can be a normal variant, and mixing of splenic vein and SMV blood (only one at a time of which will contain

contrast media), makes the interpretation of encasement of this area difficult (Fig. 3). Finally some patients will have venous encasement, but will still be resectable if only a short segment is involved and that segment is resected.

Because of difficulties in determining the presence or significance of vessel encasement, we believe that only vessel occlusion should be interpreted as an absolute sign of unresectability. Among the 62 patients in our series without vessel encasement or occlusion, 45 underwent pancreaticoduodenectomy, for a resectability rate of 77%. In 17 patients vessel encasement alone was present and six underwent pancreaticoduodenectomy, for a resectability rate of 35%. Eleven of the patients had angiographic evidence of major vessel occlusion, and none were resectable. We believe that only if there is angiographic evidence of extensive and widespread vascular encasement should encasement alone be considered as an absolute sign of unresectability.

Other means of staging patients with periampullary carcinomas also are being evaluated.<sup>16</sup> Laparoscopy can be used to identify unsuspected liver metastasis or peritoneal implants. However CT has become so accurate in identifying even small liver lesions that laparoscopy would appear to have little to add. In our series of 90 patients, only six proved to have peritoneal implants that would have been detected by laparoscopy. Three of these six had resectability excluded on the basis of vascular involvement at angiography. Fourteen of our patients underwent MRI before laparotomy. In two patients, portal vein involvement was suspected. Angiography and laparotomy failed to confirm these findings. In a third patient, SMV encasement was read and confirmed by angiography and laparotomy. Magnetic resonance imaging is superior to CT in evaluating vascular anatomy and may yet play a major role in the staging of patients with periampullary neoplasms. Dynamic CT and MRI are being evaluated and compared prospectively to angiography and laparotomy at The Johns Hopkins Hospital for their relative merits in staging. Visceral angiography provides superior resolution and is preferred. If CT is used to identify liver metastases and visceral angiography is used to identify local tumor extension causing vessel occlusion or wide spread encasement, patients can be safely and accurately selected (1) to undergo laparotomy with a high likelihood of being resectable, or (2) to be considered for nonoperative palliation, knowing the patient is unresectable.

#### Acknowledgment

The authors thank the Johns Hopkins Tumor Registry for its assistance.

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### DISCUSSION

DR. JOHN W. BRAASCH (Burlington, Massachusetts): This is an important paper, an attempt to evaluate the various modalities we have in preoperative assessment of patients with malignant obstruction of the biliary tract. It is done in sufficient numbers and the material has been carefully analyzed and very lucidly presented here by Dr. Cameron.

I would like to focus on, if I might, those cases that had total vascular occlusion. I think there were 11, of which none were resected. The assumption is made here that other means of palliation of biliary obstruction other than surgical are valid. We have taken the opposite interpretation of such data, and I would like offer an explanation. We think, in patients whose life expectancy is longer than 4 months, those patients without liver metastases, those patients without huge tumors and without multiple nodes that are obvious on CT scan, that the best palliation is a biliary tract anastomosis.

Our experience has been that with retrograde intubation of these tumors by endoscopes that there are problems with these stents such as cholangitis, slippage, and obstruction, and so on, and certainly percutaneous transhepatic tubes are very uncomfortable. These deficiencies are acceptable for patients with short expected survival times but probably not for those expected to survive for more than 4 months.

Surgery is a direct and accurate method of recognizing nonresectable cases, especially those with obstruction of the portal vein because they have evidence of collateral once the incision is made and the abdomen is viewed. Surgery also provides an opportunity to identify other causes of arterial obstruction, such as arteriosclerotic occlusion of the celiac axis or anomalous failure of collateral circulation in the arterial supply to the head of the pancreas and the liver.

For these reasons we believe that exploration is superior to arteriography in the identification of obstructed vessels. We believe, also, that we can identify the anomalies that occur in the periampullary region, and we always dissect the duodenal hepatic ligament with the thought in mind that this ligament always contains a replaced right hepatic artery or branch of it, and so we have been able to avoid damage to that artery.

I have a question for Dr. Cameron that revolves around those patients who have had encasement on their arteriogram but who were resectable. What were the margins on these resected tumors that showed vascular encasement before operation? We know that the chance of cure in a patient with cancer of the pancreas with zero margins is very minimal.

DR. ROBERT HERMANN (Cleveland, Ohio): This paper raises three issues that I would like to discuss briefly. First is the accuracy and cost-effectiveness of preoperative angiography for staging as compared to intraoperative staging by surgeons. Second is the issue that Dr. Braasch discussed, the value or benefit of avoiding operation and instead substituting either percutaneous transhepatic or endoscopic retrograde catheter drainage to palliate the jaundice when the tumor is believed to be un-

resectable. Third is the resectability rate reported by Dr. Cameron and his associates for adenocarcinoma of the head of the pancreas, which I find really astonishing; it ranged in their study from 56% to as high as 74%.

In regard to the accuracy and cost-effectiveness, we used selective celiac and superior mesenteric angiography rather frequently during the early 1970s and found it to be less accurate than intraoperative staging. In his paper Dr. Cameron reports a false-positive rate of 14% and a false-negative rate (that is resection was possible, despite the appearance of unresectability) of 29%, which makes a total combined error rate of approximately 35%. In addition, roughly two thirds of their patients had a normal study, which makes me question its overall effectiveness. It is an invasive procedure and increases patient care cost.

The second question, the one addressed by Dr. Braasch, has to do with the value or benefit of avoiding an operation and using a catheter to palliate the jaundice. Our experience is similar to their experience as well as others, that this gives less effective relief of the jaundice than does an operative bypass. The tube, if it protrudes externally, is a constant reminder to the patient of the disease. It is painful and needs to be changed every 3 or 4 months because of recurrent episodes of cholangitis. Tubes are really second-class palliation, as compared to a surgical bypass.

Finally the issue of resectability. I am amazed at the rates that you report. Our own resectability rate for adenocarcinoma, ductal type in the head of the pancreas, remains in the range of 15%, which is nowhere near your report of 56%. We find, however, that we can resect between 50% to 80% of other periampullary tumors—that is carcinoma of the ampulla, distal bile duct, periampullary duodenal cancers, or cystic carcinomas or islet cell carcinomas, but not the standard adenocarcinoma of the head of the pancreas.

I have two questions for you. First, would you tell us the cost of angiography at Johns Hopkins? What does this add to the expense to these patients? Second, would you discuss a little more thoroughly what constitutes, in your opinion, an unresectable tumor? In other words, how did you determine resectability? I think you are seeing a different group of patients than we see in Cleveland.

DR. WILEY F. BARKER (Los Angeles, California): I rise not to discuss some of the therapeutic aspects of this paper but to congratulate the authors on what they have done and to make a comment about history.

When this Society was just 42 years old, a man named Reynaldo Dos Santos, whose son became a very famous vascular surgeon, read a paper entitled 'Arteriography of the Extremities, the Aorta and Its Abdominal Branches,' and I would like to introduce into the record a very brief note from the summary of this paper.

He says, 'With regard to the abdomen and extremities, one can foresee the vast semeiologic horizon that the multiplicity of interesting aspects we have already glimpsed only with regard to the kidney. You can already