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Current Trends in Preoperative Biliary Stenting in Pancreatic Cancer Patients

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Abstract

BACKGROUND—Sufficient evidence suggests that preoperative biliary stenting is associated with increased complication rates after pancreaticoduodenectomy.

METHODS—Surveillance, Epidemiology, and End Results (SEER) and linked Medicare claims data (1992–2007) were used to identify patients with pancreatic cancer who underwent pancreaticoduodenectomy. We evaluated trends in the use of preoperative biliary stenting, timing of physician visits relative to stenting, and time to surgical resection and symptoms in stented and unstented patients.

RESULTS—Pancreaticoduodenectomy was performed in 2,573 patients. 52.6% of patients underwent preoperative biliary stenting (N=1,354). Of these, 75.3% underwent endoscopic stenting only, 18.9% received a percutaneous stent, and 5.8% underwent both procedures. The overall stenting rate increased from 29.6% of patients in 1992–95 to 59.1% in 2004–07 ($p<0.0001$). Preoperative stenting was more common in patients with jaundice, cholangitis, pruritus, or coagulopathy ($p<0.05$ for all). 77.7% of stented patients had a stent placed prior to seeing a surgeon. Stenting prior to surgical consultation was associated with longer indwelling stent time compared to stenting after surgical consultation (37.3 vs. 27.0 days, $p<0.0001$). In addition, stented patients had longer times from surgeon visit to pancreatectomy than those who were not stented (24.2 days vs. 17.2 days, $p<0.0001$).

CONCLUSION—Use of preoperative biliary stenting doubled from 1992–2007 despite evidence that stenting is associated with increased perioperative infectious complications. The majority of stenting occurred prior to surgical consultation and is associated with significant delay in time to operation. Surgeons should be involved early in order to prevent unnecessary stenting and improve outcomes.

Keywords

Pancreatic cancer; biliary stenting; endostent

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INTRODUCTION

Preoperative biliary stenting was introduced in the 1960s and 1970s in an effort to improve surgical outcomes in pancreatic cancer patients undergoing curative-intent resection. This was done to correct physiologic disturbances induced by hyperbilirubinemia secondary to malignant obstruction, theoretically optimizing patients' condition prior to operation and improving perioperative morbidity and mortality. Early retrospective studies¹⁻⁴ and small prospective randomized trials⁵⁻⁸ yielded mixed results, some finding benefit^{1-3, 5} with stenting and others finding no benefit.^{4, 6-8}

The theoretical benefits of preoperative biliary stenting have not been consistently demonstrated in practice. Large retrospective analyses comparing stented to unstented patients either report no significant differences in surgical outcome⁹⁻¹² or increased rates of infectious complications with preoperative biliary stenting.¹³⁻¹⁷ Several meta-analyses in the past decade corroborated these findings and recommend against the routine use of preoperative biliary stenting in patients undergoing pancreaticoduodenectomy.¹⁸⁻²¹ A recent prospective randomized trial reported a significantly increased overall complication rate in stented patients compared to those who proceeded directly to surgery, and many of the reported complications were related to the stenting procedure itself.²²

In the setting of this evolving literature, we used the Surveillance, Epidemiology, and End Results (SEER) tumor registry and linked Medicare claims data to examine trends in use of preoperative biliary stenting from 1992–2007. In addition, we evaluated factors that were associated with the receipt of preoperative biliary stenting. Based on clinical experience, we hypothesized that preoperative biliary stenting had not decreased over this time period and that the majority of stenting occurred prior to surgical consultation/evaluation.

METHODS

This study was approved by the Institutional Review Board at the University of Texas Medical Branch.

Data Source

We used data from the National Cancer Institute's Surveillance, Epidemiology, and End Results (SEER) tumor registry and linked Medicare claims data collected by the Center for Medicare and Medicaid Services. Developed by the National Cancer Institute, the SEER program collects information on cancer incidence and survival from population-based cancer registries currently covering approximately 28% of the U.S. population.²³ SEER provides information on patient demographics, primary tumor site, histology, stage of disease, first course of treatment, and survival status.

The Medicare data include all claims for covered health care services, including inpatient and outpatient care, for all Medicare patients. The study included patients aged 66 years and older who were diagnosed from 1992 through 2007 and their Medicare claims through 2009.²⁴

Cohort Selection (Figure 1)

Our cohort selection is summarized in Figure 1. Our cohort included patients with a primary diagnosis of adenocarcinoma of the pancreas between 1992–2007. International Classification of Disease for Oncology 3rd edition (ICD-O-3) morphology codes were used for adenocarcinoma (8000/3, 8010/3, 8020/3, 8021/3, 8022/3, 8140/3 8141/3, 8211/3, 8230/3, 8500/3, 8521/3, 8050/3, 8260/3, 8441/3, 8450/3, 8453/3, 8470/3, 8471/3, 8472/3,

8473/3, 8480/3, 8481/3, 8503/3). All International Classification of Diseases, Ninth Revision Clinical Modification (ICD-9-CM) and American Medical Association Common Procedure Terminology (CPT) codes used for the analysis are shown in Table 1. We included beneficiaries aged 66 and older who underwent pancreatic head resection within three months of diagnosis (Figure 1) and were enrolled in Medicare Part A and Part B without HMO for 6 months before and 3 months after surgery or until death. We excluded patients in whom pancreatic cancer was not the first primary and in whom the diagnosis was made at autopsy or by death certificate only.

Measures

Endoscopic and percutaneous stenting were identified using both ICD-9 procedure codes and CPT codes in the carrier, Medicare Part A inpatient billing claims (MEDPAR), and outpatient standard analytic file (SAF) (Table 1). These codes included both insertion and replacement of stents or percutaneous biliary drains and excluded isolated pancreatic duct stenting. Date of the stenting procedure was obtained from Medicare claims, with the date of the first procedure used if multiple stenting procedures were performed. ICD-9 and CPT codes for endoscopic retrograde cholangiopancreatography (ERCP) without stenting (Table 1) were not included but were used to determine presumed failed endostenting if they occurred prior to or on the same day as percutaneous stenting. We also identified newer technologies such as CT, MRI, and endoscopic ultrasound (EUS) in carrier and outpatient SAF files with the following codes (CT abdomen: ICD-9: 88.01, CPT: 74150, 74160, 74170, 74175, 76376, 76377; MRI abdomen: ICD 9: 88.97, CPT: 74181, 74182, 74183, 74185, EUS: CPT: 76975, 43231, 43232, 43259).

Patients were classified as having: 1) localized disease (AJCC 0, IA, IB), 2) regional disease (AJCC IIA, IIB, III), or 3) distant disease (AJCC IV) using the SEER historic stage.²⁵ The SEER historic stage is based on the best available data using a combination of pathologic observations, intraoperative observations, and clinical observations, in this priority order. Neoadjuvant therapy was defined as receipt of chemotherapy (Table 1) in the 6 months prior to surgical resection.

The date of surgery was determined from the associated Medicare claim. To identify the first surgeon visit, we used the carrier files to identify evaluation and management codes for office or other outpatient services and consultations and hospital inpatient services and consultations (Table 1). The Medicare Health Care Financing Administration specialty claims code associated with the claim was identified. Surgeon specialty was defined by Medicare specialty codes 02 (general surgery) and 91 (surgical oncology). The date of the first surgeon visit was defined as the date of the first visit to a surgeon before the date of surgical resection or the date of surgical resection if there was no prior documented surgeon visit. We identified the first gastroenterologist visit using evaluation and management claims for gastroenterologist (Medicare specialty code 10). The first visit was considered the date of first evaluation and management code or first endostent/ERCP code, whichever was earlier.

Demographic variables included age, gender, race, marital status, SEER region, quartiles of education, and median income. SEER-Medicare does not provide patient-level information for education and income; thus patients were placed into education and income quartiles based on zip code-level data. Zip code-level data were from the 2000 census and included median income and the percentage of residents with less than 12 years of education. Quartile 1 is the least educated (highest percentage without high school education) or lowest income quartile and quartile 4, the highest. Symptoms in the three months prior to surgery were identified using ICD-9 codes of inpatient or outpatient claims including jaundice (782.4), cholangitis (576.1), pruritus (698.9), and coagulopathy (286.7).

Statistical Analysis

Summary statistics were calculated for the entire cohort. We calculated the overall proportion of patients undergoing preoperative endoscopic or percutaneous stenting procedures. These were not mutually exclusive. Therefore, stented patients were classified as having undergone endoscopic, percutaneous, or both. In patients who underwent both endostenting and percutaneous stenting, we evaluated the relative timing of the two procedures. We also evaluated the timing of stent placement relative to surgical evaluation. Among stented patients, the proportion stented prior to seeing a surgeon was examined as were time trends in the rate of stenting prior to seeing a surgeon.

Time trends in the use of stenting procedures (overall, endoscopic, percutaneous) during the study period were examined using the Cochran-Armitage test for trend. Time trend analyses were performed using all SEER regions and then repeated excluding New Jersey, greater California, Kentucky, and Los Angeles, which were added in 2001 (first full year of data, 2000). As the results were identical, we report the results for the entire cohort.

We also evaluated the timing of stent placement relative to surgical evaluation. Among stented patients, the proportion stented prior to seeing a surgeon was examined as were time trends in the rate of stenting prior to seeing a surgeon.

Student's t-test was used to compare time from surgical visit to surgical resection in stented and unstented patients and time from stenting to surgical resection in patients stented before and after seeing a surgeon. The proportion of patients who were stented within 1 week and 2 weeks of surgery was calculated.

Frequency of symptoms in the 3 months prior to surgery (jaundice, cholangitis, pruritus, coagulopathy) was calculated for the overall cohort. Bivariate analysis (chi-square) was used to determine the unadjusted association of patient, tumor, and operative characteristics with receipt of preoperative biliary stenting. Chi-square tests were also used to compare the rates of each individual symptom between stented and unstented patients as well as patients stented before and after seeing a surgeon. Multivariate logistic regression analysis was used to determine factors independently associated with preoperative biliary stenting.

Significance was accepted at the $p < 0.05$ level. Statistical analysis was carried out using SAS Version 9.2 (Cary, N.C.).

RESULTS

Patient Demographics and Tumor Characteristics (Table 2)

2,573 patients underwent curative-intent surgical resection for adenocarcinoma of the head of the pancreas. The mean age at presentation was 73.8 ± 5.4 years. The majority of patients were female, white, and married. 2,318 patients (90.1%) had locoregional disease. One hundred forty-seven patients (5.7%) received neoadjuvant therapy in the 6 months prior to surgical resection. The distribution by SEER region is shown in Table 2. Potential indications for preoperative biliary drainage including jaundice, cholangitis, pruritus, and coagulopathy were seen preoperatively in 64.1%, 10.3%, 6.5%, and 0.7% of patients, respectively. Tumor characteristics are shown in Table 2.

Preoperative Biliary Drainage

Preoperative biliary drainage was performed in 1,354 patients (52.6%). Of these, 81.1% of patients underwent ERCP with endostenting and 24.7% underwent percutaneous biliary drainage. 75.3% of patients who underwent preoperative biliary drainage underwent endostenting only, 18.9% percutaneous stenting only, and 5.8% underwent both procedures.

In the 5.8% of patients (N=78) who received both endostenting and percutaneous drainage, 38.5% received the procedures on the same day (N=30), 24.4% had the endostent first (N=19), and 37.2% had the percutaneous biliary drain first (N=29). In patients who had a percutaneous transhepatic cholangiographic (PTC) stent only, 82.0% had an ERCP without endostent placement prior to PTC.

Time Trends in Preoperative Biliary Drainage (Figure 2)

Preoperative biliary stenting increased from 29.6% of patients in 1992–1995 to 59.1% in 2004–2007 (Figure 2, $p<0.0001$); this trend was largely attributed to an increase in the use of endostenting. The rate of endostenting increased significantly over time, from 20.2% in 1992–1995 to 49.8% in 2004–2007 (Figure 2, $p<0.0001$). The use of percutaneous stenting started at 11.5% in 1992–1995, peaked in the 1996–1999 time period at 16.7%, then returned to approximately 12% for the later two time periods (Figure 2, $p=0.16$). All time trends were identical when SEER regions that joined in 2001 were excluded (NJ, KY, greater CA, LA).

Concurrent Increase in Use of Other Tests

During the same time period, the use of several other diagnostic tests increased as well. Between 1992–1995 and 2004–2007, use of magnetic resonance imaging (MRI) increased from 1.5% to 21.6% ($p<0.0001$), CT use increased from 87.3% to 96.4%, and endoscopic ultrasound use increased from 2.7% in 1992–1995 to 16.8% in 2004–2007 ($p<0.0001$). Trends for all tests are shown in Figure 3.

Of the 1,354 patients who underwent preoperative biliary stenting, 97.1% underwent CT, 20.5% underwent MRI, and 19.9% underwent EUS. Of these, 83.7% of CT scans, 53.1% of MRIs, and 12.2% of EUSs were performed prior to stenting, suggesting that staging before stenting occurred in most patients.

Timing of Preoperative Biliary Stenting and Surgeon/Gastroenterologist Visits

For the overall cohort we were unable to identify a surgeon visit in 443 patients (17.2%). In the 1,354 patients who underwent preoperative biliary stenting, we identified preoperative surgeon visits in 1,157 (85.4%). The date of surgery was the first surgeon-related claim in 14.6%. The preoperative biliary stent was placed prior to surgical evaluation in 77.7% of stented patients (N=1,052). This decreased to 73.9% when we included only those with documented preoperative surgeon visits. 1509 (58.7%) patients saw a gastroenterologist prior to seeing a surgeon. This pattern was consistent throughout the study period for all stented patients ($p=0.55$), those that saw a surgeon before surgery ($p=0.25$), and when the SEER regions joining in 2000 were excluded (N=800, $p=0.31$).

Timing of Preoperative Biliary Stenting and Surgical Resection

There was a longer time from diagnosis to surgery in stented compared to unstented patients (mean, 41.0 ± 42.7 days vs. 32.4 ± 45.8 days; median, 30 days vs. 21 days, $p<0.0001$). In patients who underwent preoperative biliary drainage, 69.6% had an interval of longer than two weeks between stent placement and surgery. The mean time from stenting to surgical resection was 35.0 ± 35.9 days (median, 23.0 days; Interquartile range: 12–42 days). Additional stenting procedures and/or stent changes were required in 234 (17.3%) of stented patients prior to surgical intervention, and 4.7% (N = 11) of these patients had cholangitis prior to the initial stent placement. Overall, 174 patients (12.9%) had documented cholangitis after initial stent placement. Of those patients with cholangitis after stenting, none had cholangitis documented prior to initial stent placement.

In the group of patients who underwent preoperative biliary stenting, those who were stented prior to seeing a surgeon had a longer time from stenting to surgical resection compared to those who were stented after seeing a surgeon (mean, 38.6 ± 37.3 days vs. 25.3 ± 29.7 days; median, 26 days vs. 14 days, $p < 0.0001$). When we included only those with a documented surgeon evaluation prior to resection, the time from surgical consultation to surgical resection remained longer for stented compared to unstented patients (mean, 24.2 ± 28.34 days vs. 17.2 ± 26.21 days; median: 15 days vs. 8 days, $p < 0.0001$).

Factors Predicting Biliary Stenting

In an unadjusted analysis (Table 3), stenting increased with year of diagnosis. Men were more likely to undergo preoperative biliary stenting than women ($p = 0.05$). Compared to black patients, white or Hispanic patients had higher rates of stenting ($p = 0.04$). Patients in the lowest income ($p = 0.0006$) and education quartiles ($p = 0.02$) were less likely to be stented. The use of stenting was similar across Charlson comorbidity scores. Preoperative biliary stenting rates varied across SEER regions, with rates over 60% in Kentucky, Rural Georgia, Seattle, and Utah and less than 45% in Detroit, Hawaii, and Louisiana ($p < 0.0001$). There was no difference in patient demographics, preoperative symptoms, and tumor characteristics across SEER regions with enough patients to compare. Age was similar in the stented and unstented groups (73.6 ± 5.2 years vs. 73.9 ± 5.4 years, $p = 0.19$).

Preoperative biliary stenting was more common in patients with preoperative jaundice, cholangitis, pruritus, or coagulopathy. 66.2% of jaundiced patients underwent stenting compared to 28.3% of patients without jaundice ($p < 0.0001$). Similarly, patients with preoperative cholangitis (87.5% vs. 48.6%, $p < 0.0001$), pruritus (74.4% vs. 51.1%, $p < 0.0001$), and coagulopathy (76.5% vs. 52.5%, $p = 0.05$) were more likely to be stented compared to patients without the sign/symptom. However, stenting was also common in patients without these documented symptoms. We also evaluated time trends in symptoms coded in the Medicare claims to see if there was a change in presentation of patients or documentation of their presentation over time. There was no change in the number of patients with jaundice, ranging from 39% in 1992–1995 to 37% in 2004–2007 ($p = 0.48$). Only 168 patients had documented pruritus, and this increased slightly over time from 3% to 9% ($p = 0.005$). Likewise, only 265 patients had cholangitis but the percentage of patients with cholangitis increased from 5% to 13% ($p = 0.003$). Coagulopathy was stable over time around 1% ($p = 0.47$).

In patients undergoing preoperative biliary stenting, tumor size was larger than in patients who were not stented (3.5 ± 1.8 cm vs. 3.1 ± 1.6 cm, $p < 0.0001$). Stenting was more common in patients with regional disease.

Preoperative biliary stenting was more common in the 147 patients undergoing neoadjuvant therapy than in patients who did not (63.3% vs. 52.0%, $p = 0.008$). Finally, patients who saw a gastroenterologist prior to seeing a surgeon were more likely to undergo preoperative biliary stenting (60.7% vs. 41.2%, $p < 0.0001$).

There was no significant difference in the frequency of jaundice, cholangitis, or pruritus between the groups of patients stented before and after seeing a surgeon. Patients who were stented after seeing a surgeon were more likely to be coagulopathic compared to patients who were stented before seeing a surgeon ($p = 0.0006$).

On multivariate logistic regression analysis (Table 4), the following factors were independently associated with receiving a preoperative biliary stent: later year of diagnosis, preoperative jaundice and cholangitis, larger tumor size, neoadjuvant therapy, and gastroenterologist visit prior to surgeon visit. The likelihood of undergoing preoperative

biliary stenting varied significantly with SEER region. There was no difference in patient/tumor characteristics across SEER regions.

DISCUSSION

Despite evidence of increased complication rates and recommendations to avoid routine preoperative biliary stenting, the use of preoperative biliary stenting doubled between 1992 and 2007. The increase in preoperative biliary stenting was driven by a rise in the use of endostenting, while percutaneous stenting was used at a constant rate throughout the study period. Our population-based study found that 77% of patients are referred to a surgeon with a stent already in place, consistent with previous single institution studies reporting rates of 42%–79%.^{26–29} Moreover, evaluation by a gastroenterologist prior to surgeon evaluation was associated with increased stenting.

The literature surrounding the issue of preoperative biliary stenting has long generated controversy amidst evolving stent technology and techniques, and advances in surgical technique and perioperative care. Several large retrospective analyses comparing stented to unstented patients demonstrated either no difference in outcome^{9–11} or increased rates of mortality,¹⁴ overall complications,^{13, 14, 27} overall infectious complications,^{14, 30} wound infection,^{13–17, 19, 27, 30} intraabdominal abscess,^{13, 14, 30} or pancreatic fistula formation^{15, 27, 30} with preoperative biliary stenting. Two meta-analyses in 2002^{18, 21} showed no difference in outcome between stented and unstented patients and later meta-analyses in 2010 and 2011 demonstrated increased infectious complications.^{19, 20} A multicenter randomized controlled trial by van der Gaag et al. in 2010 assigned patients to either an early surgery group (resection within 1 week of diagnosis) or a drainage group (endostenting with 4–6 week drainage period prior to surgery).²² The severe complication rates in the early surgery group and the biliary drainage group were 39% and 74%, respectively (relative risk = 0.54; 95% CI: 0.41–0.71; $p < 0.0001$). A significant proportion of complications were related to the stenting procedure itself and not postoperative complications.

To our knowledge, our study is the first to evaluate trends in preoperative biliary stenting at the population level. In our multivariate analysis, we observed that patient symptoms and signs (jaundice, cholangitis, pruritus) were most strongly associated with biliary stenting, consistent with prior observations.^{9, 14, 15, 31} However, stenting was also performed in 28% of patients without documented jaundice and approximately 50% of patients without cholangitis, pruritus, or coagulopathy. In addition, we observed significant geographic variation in the use of preoperative biliary stenting, with no evidence of differences in patient characteristics across SEER regions. This suggests that stenting was done based on provider preference and not patient or tumor characteristics.

Preoperative biliary stenting is indicated in patients who will undergo neoadjuvant therapy prior to surgical intervention. Previous studies have documented the safety and efficacy of preoperative stenting in this setting.^{32–34} In our study, only 147 patients underwent neoadjuvant therapy. Of these patients, 93 (63.3%) underwent preoperative stenting. In the setting of neoadjuvant therapy, stenting is appropriate to palliate jaundice while awaiting completion of therapy and restaging. However, of the 2,426 patients who did not undergo neoadjuvant therapy, 1,261 (52.0%) underwent preoperative biliary stenting. The observed increase in biliary stenting is not explained by an increase in receipt of neoadjuvant therapy in our cohort, as the use of neoadjuvant therapy did not change over time.

The median time from stenting to surgical resection was 35 days, and 70% of patients had delays of greater than two weeks from stenting to resection. Consistent with the recent

randomized controlled trial²², we also observed significant complication rates related to the stenting procedure. Our study demonstrated that 13% of stented patients developed documented cholangitis and 17% required additional stenting procedures or stent changes prior to resection. A 2002 meta-analysis of randomized controlled trials reported drainage procedure-related complications in 27.4% and stent dysfunction in 33.8% of patients.¹⁸ Previous studies have documented hepatotoxicity, stent migration, and cholangitis as factors that may delay resection and may account for the long delay between stenting and surgical resection.^{10, 33, 35, 36} Conversely, the need for stent changes and development of cholangitis may be secondary to the delay and not vice versa.

The delay from diagnosis to resection was longer if the stent was placed prior to surgical evaluation, consistent with previous studies suggesting longer times to surgery for stented patients.^{9–11, 27} It is well documented that preoperative biliary stenting colonizes the biliary tree with enteric flora.^{12, 19, 27, 28, 35, 37, 38} In addition, colonization and infection increase with increased duration of stenting and the presence of biliary contamination/infection is associated with increased rates of postoperative infectious complications and mortality^{10, 19, 27, 28, 35}

Our study has several limitations. First, laboratory results such as bilirubin levels and liver function tests are not available in the SEER-Medicare data. Second, symptoms such as jaundice, cholangitis, coagulopathy, or pruritis are likely undercoded in claims data. Thus, we may overestimate stenting in asymptomatic patients. For example, it is possible that patients in the “non-jaundiced” group (ie. no claim for jaundice) actually had mildly elevated bilirubin or alkaline phosphatase levels, meaning the denominator would be lower.

In 14.6% of stented patients, we were unable to identify a surgeon visit prior to resection. We suspect that many of these patients were seen by surgeons as inpatients, and the surgeon visit was not documented in the hospital claim. It is also possible that there are errors in the Medicare physician specialty codes. For this reason, we evaluated stenting prior to surgical evaluation both in the overall cohort (using the date of surgery as the date of surgeon visit when no preoperative visit was identified) and in the subgroup with identified preoperative surgeon consultations. Finally, as our study goes through 2007, several of the studies recommending against its use occurred after the time period of our study and recent trends may have changed.

There are many situations, even in resected patients, where stenting is warranted. For example, stenting is appropriate in patients who need neoadjuvant chemoradiation and patients with severe symptoms related to their jaundice. Stenting may also be indicated in patients with significant comorbid medical illness who need further evaluation and optimization/stabilization of their medical conditions prior to surgery. In addition, stenting may be unavoidable in settings where operating room, surgeon, or patient availability is limited. There was no concomitant increase in jaundice over time to suggest the increase in stenting is clinically justified. Pruritus and cholangitis increased slightly over time. While it is impossible to tell if this increase represents a true change in symptoms or better coding, the small number of patients involved does not explain the doubling in stent rates. While we cannot determine the appropriateness of stenting in any specific instance, the increasing trend is concerning in light of consistent recommendations against the routine use of biliary stenting. Furthermore, geographic variation in use of stenting, coupled with an increase in the use of many other preoperative tests (EUS, MRI, CT), suggests a more widespread problem of overuse.^{39–43} In stented patients, the majority of diagnostic and staging tests were performed prior to stenting, suggesting careful staging. This provides additional evidence that referral patterns, and not the clinical picture, are driving preoperative biliary

stenting; patients with staged, resectable disease are often being referred to gastroenterology before surgical evaluation without communication between the two specialties.

In conclusion, we demonstrated that preoperative biliary stenting has increased at an alarming rate despite consistent recommendations against its use. The majority of stenting occurred prior to surgical evaluation and was more likely if patients had symptoms or were seen by a gastroenterologist first. Biliary stenting was associated with a delay to surgery, which may have been due to stenting-related complications. These findings highlight the need for early communication between gastroenterologists and surgeons in the care of patients with pancreatic and other periampullary cancers. Multidisciplinary tumor boards are potential means to reduce unnecessary stenting and improve patient outcomes. Early surgeon involvement and multidisciplinary care offer opportunities for streamlining the evaluation of patients with early stage pancreatic cancer to avoid unnecessary procedures and improve processes of care for this patient population.

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Figure 1.

Cohort Selection. We included all patients with a first primary diagnosis of pancreatic adenocarcinoma between 1992–2007. Only patients age 66 and older with histologically confirmed and surgically resected adenocarcinoma within 3 months of diagnosis were included. Patients were excluded if they did not have Medicare Part A and B without HMO for six months before and three months after surgery.

Stenting Procedures Over Study Period 1992-2007

Figure 2.

Trends in Stenting Over Study Period, 1992–2007. Preoperative biliary stenting increased steadily over the study period, from 29.6% of patients in 1992–1995 to 59.1% of patients in 2004–7, $p < 0.0001$. This increase is accounted for primarily by an increase in the rate of endostenting, from 20.2% of patients in 1992–1995 to 49.8% in 2004–2007 ($p < 0.0001$).

Other Diagnostic Tests Over Study Period 1992-2007

Figure 3.

Trends in Use of Other Diagnostic Tests, 1992–2007. Preoperative diagnostic test use increased significantly during the study period. Computed tomography (CT) use increased from 87.3% to 96.4%, MRI from 1.5% to 21.6%, and EUS from 2.7% to 16.8% ($p < 0.0001$ for all).

Table 1

ICD-9-CM and CPT Codes for Preoperative Procedures, Surgeon Visits, and Symptoms

	ICD-9 Codes	CPT/HCPCS codes
<u>Procedures</u>		
Pancreatic head resection	52.6, 52.7, 52.51	48150, 48152, 48153, 48154, 48155
ERCP	51.10, 51.11, 51.84–51.87, 51.99, 52.13, 52.93	74328–74330, 43260–43269, 43271, 43272
With endostent	51.86, 51.87, 51.99	43267–43269
Without endostent	51.10, 51.11, 51.84, 51.85, 52.13, 52.93	74328–74330, 43260–43266, 43271, 43272
PTC/ drain	51.98, 87.51	74320
Chemotherapy *	ICD-9 diagnosis codes: V58.1, V66.2, V67.2; ICD-9 procedure codes: 99.25; DRG code: 410	HCPCS/CPT codes: 96400- 96549, Q0083, Q0084, Q0085, J7150, J2353, J2354, J9000- J9999; Revenue center codes: 0331, 0332, 0335
CT Abdomen	88.01	74150, 74160, 74170, 74175, 76376, 76377
MRI Abdomen	88.97	74181, 74182, 74183, 74185
EUS	NA	76975, 43231, 43232, 43259
<u>Surgeon Visits</u>		
Outpatient Evaluation and Management	NA	99201–99205, 99211–99215, 99241–99245
Inpatient Evaluation and Management	NA	99221–99223, 99231–99236, 99238, 99251–99255
<u>Symptoms</u>		
Jaundice	782.4	NA
Cholangitis	576.1	NA
Pruritis	698.9	NA
Coagulopathy	286.7	NA

* Neoadjuvant therapy defined as chemotherapy in the 6 months prior to surgical resection.

ERCP=endoscopic retrograde cholangiopancreatography, PTC= percutaneous transhepatic cholangiogram, CT= computed tomography, MRI= magnetic resonance imaging, EUS= endoscopic ultrasound, NA= not applicable

Table 2

Patient Demographics and Tumor Characteristics

	Number (%) N=2,573
Patient Demographics	
Age (mean $\pm$ SD, years)	73.8 $\pm$ 5.3
Female	1,400 (54.4)
Race	
White	2,222 (86.4)
Black	164 (6.4)
Hispanic	30 (1.2)
Other	157 (6.1)
Married	1,578 (62.9)
Charlson comorbidity score	
0	1136 (44.1)
1	826 (32.1)
2	360 (14.0)
3+	251 (9.8)
SEER Region	
Atlanta	88 (3.4)
Connecticut	257 (10.0)
Detroit	304 (11.8)
Greater California	331 (12.9)
Hawaii	57 (2.2)
Iowa	181 (7.0)
Kentucky	150 (5.8)
Los Angeles	229 (8.9)
Louisiana	125 (4.9)
New Jersey	371 (14.4)
New Mexico	62 (2.4)
San Francisco	101 (3.9)
San Jose	95 (3.7)
Seattle	120 (4.7)
Utah	99 (3.9)
Preoperative Signs/Symptoms	
Jaundice	1650 (64.3)
Cholangitis	265 (10.3)
Pruritis	168 (6.5)
Coagulopathy	17 (0.7)
Tumor Characteristics and Treatment	

	Number (%) N=2,573
Local/regional stage	2,318 (90.1)
Tumor size in cm (N=2,269)	3.3 ± 1.7
Well/moderately differentiated	1,414 (55.0)
Positive lymph nodes (N=2,304)	1,402 (60.9)
Neoadjuvant therapy	147 (5.7)

Table 3

Bivariate Analysis: Factors Associated with Receipt of Preoperative Biliary Stenting

	% Undergoing Preoperative Biliary Stenting	p-value
Year of Diagnosis		<0.0001
1992–1995	29.6%	
1996–1999	47.1%	
2000–2003	55.9%	
2004–2007	59.1%	
Patient Demographics		
Sex		0.05
Male	54.7%	
Female	50.9%	
Race		0.04
White	53.7%	
Black	45.7%	
Hispanic	56.7%	
Other	44.6%	
Marital Status		0.21
Married	53.6%	
Unmarried	51.1%	
Charlson comorbidity score		0.36
0	52.2%	
1	51.0%	
2	55.6%	
3+	55.8%	
Income Quartiles		0.0006
Quartile 1 (lowest)	45.6%	
Quartile 2	55.6%	
Quartile 3	55.2%	
Quartile 4 (highest)	54.4%	
Education Quartiles		0.02
Quartile 1 (lowest)	47.5%	
Quartile 2	55.6%	
Quartile 3	54.6%	
Quartile 4 (highest)	53.2%	
SEER Region		<0.0001
Atlanta	53.4%	
Connecticut	51.0%	
Detroit	44.7%	
Greater California	56.5%	

	% Undergoing Preoperative Biliary Stenting	p-value
Hawaii	40.4%	
Iowa	49.2%	
Kentucky	62.0%	
Los Angeles	47.2%	
Louisiana	43.2%	
New Jersey	59.3%	
New Mexico	45.2%	
Rural Georgia	66.7%	
San Francisco	46.5%	
San Jose	51.6%	
Seattle	63.3%	
Utah	64.6%	
Preoperative Signs/Symptoms		
Jaundice		<0.0001
Yes	66.2%	
No	28.3%	
Cholangitis		<0.0001
Yes	87.6%	
No	48.6%	
Pruritus		<0.0001
Yes	74.4%	
No	51.1%	
Coagulopathy		0.05
Yes	76.5%	
No	52.5%	
Tumor Characteristics and Treatment		
Stage (N=2,496)		0.0002
Localized	44.1%	
Regional	55.0%	
Distant	47.8%	
Differentiation		0.49
Poor	53.7%	
Nodal status (regional disease only) (N=1,979)		0.22
Positive	55.7%	
Negative	52.7%	
Neoadjuvant therapy		0.008
Yes	63.3%	
No	52.0%	
Gastroenterologist visit before surgeon visit		<0.0001

	% Undergoing Preoperative Biliary Stenting	p-value
Yes	60.7%	
No	41.2%	

Table 4

Multivariate Analysis: Factors Associated with Preoperative Biliary Stenting

Factor	Odds Ratio	95% CI
Patient Demographics		
Age (per year)	0.99	0.97–1.01
Year of Diagnosis	1.09	1.06–1.12
Male (Female)	1.14	0.92–1.41
Race		
White	0.95	0.61–1.47
Hispanic	1.27	0.45–3.59
Black	Reference	Reference
Other	0.88	0.47–1.66
Married (Unmarried)	1.13	0.91–1.41
Income quartiles		
Quartile 1	Reference	Reference
Quartile 2	1.29	0.93–1.80
Quartile 3	1.15	0.78–1.71
Quartile 4	1.05	0.67–1.67
Education		
Quartile 1	Reference	Reference
Quartile 2	1.24	0.89–1.72
Quartile 3	1.20	0.82–1.76
Quartile 4	1.01	0.66–1.57
SEER Region*		
Atlanta	1.72	0.83–3.55
Connecticut	2.02	1.10–3.71
Detroit	1.66	0.93–2.97
Greater California	1.90	1.09–3.31
Hawaii	1.11	0.44–2.80
Iowa	1.48	0.80–2.74
Kentucky	2.62	1.36–2.05
Louisiana	Reference	Reference
Los Angeles	2.02	1.10–3.71
New Jersey	1.79	1.01–3.15
New Mexico	0.84	0.33–2.12
San Francisco	1.53	0.75–3.12
San Jose	1.94	0.92–4.06
Seattle	3.89	1.98–7.65
Utah	3.37	1.66–6.88
Preoperative Signs/Symptoms		

Factor	Odds Ratio	95% CI
Jaundice (no jaundice)	5.53	4.40–6.95
Cholangitis (no cholangitis)	6.33	3.98–10.08
Pruritus (no pruritus)	1.58	1.02–2.45
Coagulopathy (no coagulopathy)	2.119	0.53–8.44
Tumor Characteristics and Treatment		
Tumor size (per 10 mm)	0.99	0.98–0.99
Stage		
Localized	Reference	Reference
Regional	1.26	0.90–1.78
Distant	1.10	0.64–1.90
Differentiation (N=2,229)		
Poor (vs. No)	0.87	0.70–1.08
Nodal status (N=2,304)		
Positive	1.10	0.87–1.40
Negative	Reference	Reference
Neoadjuvant therapy		
Yes (vs. No)	2.71	1.58–4.66
Gastroenterologist visit before surgeon visit		
Yes (vs. No)	1.80	1.46–2.22

* Louisiana was chosen as reference because of low usage of preoperative biliary stenting amidst a sizable patient population. Rural Georgia was excluded because of few patients (N=3).