PAPER

Ten-Year Experience With 733 Pancreatic Resections

Changing Indications, Older Patients, and Decreasing Length of Hospitalization

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Hypothesis: Experience with pancreatic resection for the last 10 years has resulted in new trends in patient characteristics and, for pancreaticoduodenectomy (PD), a decrease in the length of stay (LOS). This decrease is due in part to the implementation of case management and clinical pathways.

Design: Retrospective case series of patients undergoing pancreatic resection.

Setting: A university-affiliated, tertiary care referral center.

Patients: The study comprised 733 consecutive patients undergoing pancreatic resection for benign or malignant disease at the Massachusetts General Hospital in Boston from April 1990 to March 2000.

Interventions: Of the 733 pancreatic resections, 489 were PD; 190, distal pancreatectomy; 40, total pancreatectomy; and 14, middle-segment pancreatectomy.

Main Outcome Measures: Length of stay; occurrence of delayed gastric emptying, pancreatic fistula, reoperation, readmission, or other complications; mortality; and comparison of patients in 3 periods according to the implementation of case management (July 1995) and clinical pathways (September 1998).

Results: For PD, patients in group 1 (April 1990 to June 1995) were significantly younger (mean ± SD, 57 ± 15 years) than those in group 2 (July 1995 to August 1998; mean ± SD, 62 ± 13 years) and group 3 (September 1998 to October 2000; mean ± SD, 65 ± 13 years) ($P<.01$). Over time, the proportion of PD for cystic tumors increased from 9.9% to 20% ($P=.01$), and the proportion of PD for chronic pancreatitis decreased from 23% to 10% ($P<.01$). Use of pylorus-preserving PD decreased from 45% to 0% ($P<.001$). Delayed gastric emptying decreased from 17% to 6.1% ($P<.01$). Pancreatic fistula, reoperation, and mortality were unchanged. Length of stay for PD decreased from 16.1 ± 0.6 to 9.5 ± 0.4 days (mean ± SE) ($P<.001$). Multivariate analysis showed that period, case volume, pylorus-preserving PD, and presence of complications are all independent predictors of LOS ($P<.05$ for all). For distal pancreatectomy, patients in groups 2 and 3 were older than those in group 1 (mean ± SD, 57 ± 14 vs 52 ± 17 years) ($P<.05$). Resections for cystic tumors increased from 26% to 52% ($P<.05$), and resections for chronic pancreatitis decreased from 32% to 14% ($P=.06$). Median LOS decreased from 9 days to 6. For total pancreatectomy, resections for cystic tumors increased from 18% to 43%. Median LOS decreased from 14.5 days to 11. For all resections, case volume increased from 4 resections per month in 1990 to 5.8 in 1995 and 12 in 2000 ($r=0.83$; $P<.001$).

Conclusions: Older patients are increasingly being selected for pancreatic resection. This reflects an increasing frequency of operations performed for cystic tumors and fewer for chronic pancreatitis. With the exception of delayed gastric emptying, complications and mortality have remained the same or decreased slightly during the past 10 years. However, there has been a significant decrease in LOS; this is the result of implementation of case management and clinical pathways, increasing case volume, decreasing incidence of delayed gastric emptying, and decreasing use of pylorus-preserving PD.

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HISTORICALLY, operative resection of the pancreas was generally regarded with skepticism. This led to the recommendation by some surgeons that procedures such as pancreaticoduodenectomy (PD) be abandoned altogether.[1-2] During the past 20 years, however, pancreatic resection has gained increasing acceptance as an effective and safe method of treating malignant and benign diseases of the pancreas.[3-8] Whereas some community-based centers of excellence have obtained very good results with pancreatic resection,[9] most advances in operative technique and perioperative care of these challenging patients have been made in referral-based regional academic centers.[10-12]

As pancreatic resection has become safer, the indications for resection have broadened, and the operations themselves have evolved. Although pancreatic resection is well established in the treatment of pancreatic adenocarcinoma and

PATIENTS AND METHODS

The medical records of 733 consecutive patients undergoing pancreatic resection, performed by the senior authors (A.L.W., D.W.R., and C.F.C.) between April 1990 and March 2000, were reviewed retrospectively. The procedures comprised 489 PDs, 190 DPs, 40 total pancreatectomies (TPs), and 14 MPs. Case management at the Massachusetts General Hospital in Boston began in July 1995, and clinical pathway implementation for pancreatic resection patients was initiated in September 1998. Accordingly, patients were divided into 3 periods: group 1 (April 1990 to June 1995), group 2 (July 1995 to August 1998), and group 3 (September 1998 to March 2000).

Perioperative parameters included patient age, type of operation (PD, pylorus-preserving PD, DP, spleen-sparing DP, TP, or MP), and pathologic diagnosis (pancreatic adenocarcinoma, periampullary tumor, CP, cystic tumor, or other). Periampullary tumors included benign and malignant neoplasms of the distal common bile duct, ampulla of Vater, and duodenum. Cystic tumors included benign mucinous cystic neoplasms, mucinous cystadenocarcinomas, serous cystadenomas, intraductal papillary mucinous tumors, and solid and papillary neoplasms. All other final histologic diagnoses were categorized as "other."

Postoperative outcomes included LOS, development of pancreatic fistula, development of delayed gastric emptying, reoperation, readmission, development of other complications, and mortality. Length of stay was measured as the total length of patient hospitalization. Pancreatic fistula was defined as the drainage of more than 30 mL/d of amylase-rich fluid from intraoperatively placed drains after postoperative day 7 or as the continued use of an intraoperatively placed drain at the time of discharge (regardless of the postoperative day or amount). Delayed gastric emptying was defined as the failure to maintain oral intake by postoperative day 14. Mortality was defined as death during the resection hospitalization or within 30 days of discharge after resection. Other complications were defined as any of the following: wound infection (culture-positive purulent drainage from the postoperative wound, requiring open packing); cholangitis (fever, leukocytosis, and culture-positive bilious drainage from operative or percutaneous drains); urinary tract infection (culture-positive urine with urinalysis-proven pyuria and bacteriuria); pneumonia (fever, leukocytosis, culture-positive sputum with polymorphonuclear leukocytes on Gram stain, and chest radiograph demonstrating focal infiltrates); bile leak (bilious drainage from peripancreatic, intraoperatively placed drains or radiographically proven fluid collection requiring percutaneous drainage and demonstrating elevated bilirubin levels); gastrointestinal bleeding (any guaiac-proven hematemesis, hematochezia, or melena requiring blood product transfusion or reoperation); myocardial infarction (characteristic elevation of serum creatine kinase or troponin levels with or without accompanying electrocardiographic changes); intra-abdominal abscess (culture-positive purulent drainage obtained from a percutaneous or operative intervention); pulmonary embolus (radiographically proven pulmonary perfusion abnormality in the setting of hypoxemia or respiratory distress, requiring anticoagulation therapy); deep venous thrombosis (characteristic venous obstruction of an involved extremity, demonstrated on Doppler ultrasound); central line infection (culture-positive line segment from an erythematous or purulent insertion site); bacteremia (culture-positive blood sample from 2 culture bottles with at least 1 from a peripheral site); arrhythmia (characteristic electrocardiographic abnormality with or without symptoms, requiring pharmacologic or electrical intervention); cerebrovascular accident (characteristic neurologic findings on physical examination with radiographically proven lesion); splenic infarct (radiographically proven infarct of at least 30% of the splenic parenchyma); and *Clostridium difficile* colitis (stool sample positive for the organism, requiring antimicrobial therapy).

Patient age is summarized as mean ± SD, whereas continuous outcomes are given as mean ± SEM. Medians are also given for selected continuous data where specified. Statistical methods involved the use of the *t* test, Fisher exact test, and Pearson correlation coefficient in the comparison of patient and operative characteristics and outcomes. The *t* test and Pearson correlation coefficient were used in univariate analysis of LOS. Multiple linear regression was used for multivariate analysis of LOS. Statistical significance was defined as $P<.05$.

The indications and outcomes of the 14 patients who underwent MP will not be described because 12 of them were the subject of a recent report by our group.[26]

For PD, we chose to examine the influence of case management and clinical pathways on the LOS. In practical terms, *case management* refers to the implementation of a case manager as part of the surgical team caring for patients on a given surgical ward. That individual examines the patient's record preoperatively and becomes familiar with patient history and individualized operative strategy. Case managers introduce themselves to the patient on the first or second postoperative day and, from that day forward, assist or take the initiative in monitoring the patient's progress, suggesting care strategies, and planning for the patient's eventual discharge to home or a rehabilitation or skilled-nursing facility. The clinical pathway for PD consists of a set of prewritten postoperative orders that prescribe major milestones in the patient's postoperative progress. For example, our clinical pathway for PD calls for removal of the nasogastric tube on the first or second postoperative day and the removal of closed-suction drains on the fifth or sixth postoperative day. The pathway provides the patient and caregivers with a goal-oriented approach to postoperative recovery.

other periampullary neoplasms, an increasing number of intraductal papillary mucinous tumors and other cystic neoplasms are being identified for resection.[4,13-15] Pancreatectomy is also frequently used in chronic pancreatitis (CP),[6,16-19] and resection of metastases to the pancreas has been described.[6,20] During the past 20 years, PD has undergone modification to include pylorus-preserving procedures and duodenum-sparing procedures.[6,21-23] Distal pancreatectomy (DP) is being performed with greater regard for splenic preservation,[24,25] and middle pancreatectomy (MP) is now part of the surgical armamentarium.[26]

The escalating standards and widening indications for pancreatic resection have led to greater expectations with regard to patient outcomes. Many series now report mortality rates of 5% or less and total complication rates of less than 40% to 50%.[4,6,7,18,23] Experienced centers are now reporting length of stay (LOS) data to assess effectiveness of

Table 1. Patient Characteristics and Operative Descriptors*

Type of Operation	Period		
	Group 1: April 1990 to June 1995	Group 2: July 1995 to August 1998	Group 3: September 1998 to March 2000
PD			
No. of resections	201	158	130
Mean ± SD age, y	57 ± 15	62 ± 13†	65 ± 13†
Pathologic diagnosis			
Pancreatic adenocarcinoma	69 (34)	53 (34)	49 (38)
Chronic pancreatitis	46 (23)	34 (22)	13 (10)‡
Cystic tumor	20 (9.9)	25 (16)	26 (20)†
Periampullary tumor	49 (24)	40 (25)	30 (23)
Other	17 (8.5)	6 (3.8)	12 (9.2)
Pylorus-preserving PD	90 (45)	21 (13)†	0 (0)‡
DP			
No. of resections	97	64	29
Mean ± SD age, y	52 ± 17	57 ± 14†	57 ± 13
Pathologic diagnosis			
Pancreatic adenocarcinoma	14 (14)	10 (16)	4 (17)
Chronic pancreatitis	31 (32)	18 (28)	4 (14)
Cystic tumor	26 (26)	21 (33)	15 (52)†
Other	26 (27)	15 (23)	5 (17)
Spleen-sparing DP	21 (22)	18 (28)	12 (41)
TP			
No. of resections	22	11	7
Mean ± SD age, y	50 ± 15	57 ± 13	58 ± 23
Pathologic diagnosis			
Pancreatic adenocarcinoma	4 (18)	5 (45)	0 (0)
Chronic pancreatitis	11 (50)	2 (18)	1 (14)
Cystic tumor	4 (18)	1 (9)	3 (43)
Periampullary tumor	0 (0)	0 (0)	1 (14)
Other	3 (14)	3 (27)	2 (29)

*Data are presented as number (percentage) of patients unless otherwise indicated. PD indicates pancreaticoduodenectomy; DP, distal pancreatectomy; and TP, total pancreatectomy.

†P<.05 vs group 1.

‡P<.05 vs groups 1 and 2.

operative treatment and perioperative care and to aid in reducing medical costs.[4,6,16,18,25,27,28] In an effort to optimize patient care and to decrease LOS, many specialized centers have begun to adopt case management strategies.[29] In a similar vein, standardized clinical pathways have been created for patients receiving major gastrointestinal operations, and these may be improving the efficiency of care.[28,30]

The objective of this study was to examine trends in patient characteristics, indications for operation, and length of postoperative hospitalization in patients undergoing pancreatic resection at our institution during a 10-year period, and in particular to determine if case management and clinical pathways have resulted in decreased LOS.

RESULTS

PATIENT AND OPERATIVE DESCRIPTORS

The patient and operative characteristics for PD, DP, and TP are provided in **Table 1**. For PD, the mean (±SD) patient age increased significantly as time went on (from 57 ± 15 years to 65 ± 13 years; $P<.001$). There was a significant decrease in the proportion of PDs performed for CP (23% vs 10%; $P=.003$), with a commensurate increase in those done for cystic tumors (9.9% vs 20%; $P=.01$); however, the percentage of PDs done for pancreatic cancer and periampullary neoplasms remained stable during the 10-year period. A marked decrease in the use of pylorus-preserving PD was seen during the study period: from 45% to 13% in the first 2 periods, and 0% in the third period ($P<.001$).

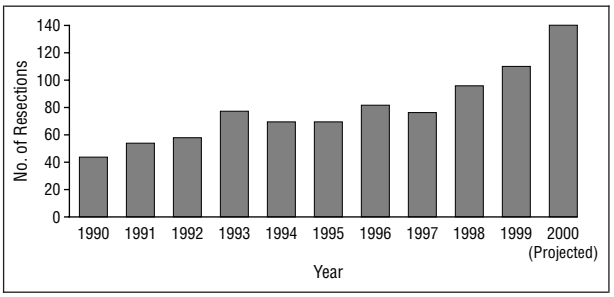

Figure 1. *Pancreatic resection volume per 12-month period at the Massachusetts General Hospital, Boston, from 1990 to 2000. Each 12-month period begins in April of the designated year and continues through March of the following year.*

For DP, the mean (±SD) patient age also increased significantly, from 52 ± 17 years to 57 ± 13 years ($P=.04$ comparing group 1 with group 2). A similar change in the proportion of resections performed for CP was seen, with a decrease from 32% to 14% ($P=.06$), and with a marked increase in DPs for cystic tumors (26% to 52%; $P=.02$). The proportion of spleen-sparing DPs increased substantially during the study period, from 21% (group 1) to 28% (group 2) to 42% (group 3) ($P=.05$, comparing group 1 with group 3).

Figure 1 depicts the increase in the total number of pancreatic resections performed on a yearly basis at

Table 2. Clinical Outcomes and Complications*

Type of Operation	Period Group 1: April 1990 to June 1995	Group 2: July 1995 to August 1998	Group 3: September 1998 to March 2000
PD			
No. of resections	201	158	130
Mean ± SEM length of stay, d	16.1 ± 0.6 (median = 14)	12.2 ± 0.5† (median = 11)	9.5 ± 0.4‡ (median = 8)
Pancreatic fistula	19 (9.5)	25 (16)	12 (9.2)
Delayed gastric emptying	34 (17)	18 (11)	8 (6.1)†
Reoperation	4 (2.0)	4 (2.5)	2 (1.5)
Readmission	15 (7.5)	18 (11)	14 (11)
Other complications	43 (21)	22 (14)	11 (8.5)†
Death	2 (1.0)	3 (1.9)	0 (0)
DP			
No. of resections	97	64	29
Mean ± SEM length of stay, d	9.9 ± 0.5 (median = 9)	9.5 ± 0.8 (median = 7)	7.8 ± 1.2 (median = 6)
Pancreatic fistula	12 (12)	11 (17)	4 (14)
Reoperation	2 (2.1)	4 (6.3)	0 (0)
Readmission	13 (13)	7 (11)	5 (17)
Other complications	12 (12)	2 (3.1)†	0 (0)
Death	2 (2.1)	1 (1.6)	0 (0)
TP			
No. of resections	22	11	7
Mean ± SEM length of stay, d	16.3 ± 1.3 (median = 14.5)	15.7 ± 2.0 (median = 14)	11.3 ± 1.6 (median = 11)
Delayed gastric emptying	2 (9.1)	3 (27)	1 (14)
Reoperation	0 (0)	0 (0)	0 (0)
Readmission	0 (0)	1 (9.1)	1 (14)
Other complications	0 (0)	0 (0)	0 (0)
Death	0 (0)	0 (0)	0 (0)

*Data are presented as number (percentage) of patients unless otherwise indicated. PD indicates pancreaticoduodenectomy; DP, distal pancreatectomy; and TP, total pancreatectomy.

†P<.05 vs group 1.

‡P<.05 vs groups 1 and 2.

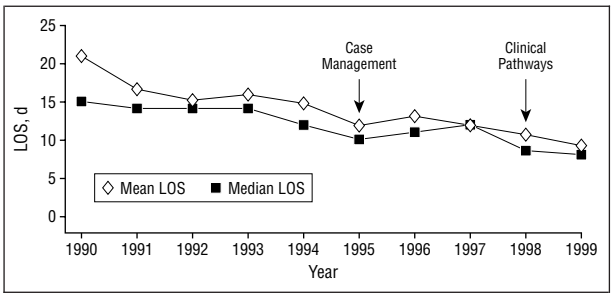

Figure 2. *Decrease in average and median length of stay (LOS) for pancreaticoduodenectomy at the Massachusetts General Hospital, Boston, from 1990 to 2000. Mean and median LOS for the 12-month period beginning in April of the designated year through March of the following year are plotted vs year of interest.*

the Massachusetts General Hospital from April 1990 to March 2000. For both PD and all resections combined, the number of cases per 6-month period increased significantly (Pearson $r=0.83$; $P<.001$ for PD and all resections combined; data not shown graphically). The number of resections increased from 4 per month in 1990 to 5.8 in 1995 and 12 in 2000.

OUTCOMES AND COMPLICATIONS

Clinical outcomes for PD, DP, and TP are listed in **Table 2**. For PD, the LOS (mean±SE) decreased from 16.1±0.6 days (group 1) to 12.2±0.5 days (group 2) to 9.5±0.4 days (group 3) ($P<.001$). **Figure 2** illustrates the decrease in mean and median LOS for PD during the past 10 years. Pancreatic fistula, reoperation, and mortality did not change significantly for PD. The proportion of patients experiencing delayed gastric emptying decreased during the study period from 16.9% (group 1) to 6.2% (group 3) ($P=.004$). Likewise, the proportion of patients experiencing other complications decreased from 21% (group 1) to 14% (group 2) to 8.5% (group 3) ($P<.05$). Readmission rate for PD did not change significantly and is currently 11%.

For DP, mean LOS did not change significantly, but median LOS decreased among the 3 groups from 9 to 7 to 6 days.Pancreatic fistula, reoperation, readmission, and mortality did not change significantly as time passed. The proportion of patients experiencing other complications decreased from 12% to 3.1% to 0% during the 3 periods ($P<.05$ between groups 1 and 2).

For TP, the mean LOS did not change significantly, but median LOS decreased among the 3 groups, from 14.5 to 14 to 11 days.Proportions of complications were difficult to analyze given the small sample size.

Categorization of complications for all resections is provided in **Table 3**.

UNIVARIATE AND MULTIVARIATE ANALYSIS OF LOS IN PD

Table 4 contains the results of univariate analysis in examining LOS outcomes for PD. Univariate analysis

Table 3. Complications by Type of Resection*

Complication	PD (n = 489)	DP (n = 190)	TP (n = 40)
Pancreatic fistula	56 (11)	27 (14)	. . .
Delayed gastric emptying	60 (12)	. . .	6 (15)
Mortality	5 (1.0)	3 (1.6)	0 (0)
Reoperation	10 (2.0)	6 (3.2)	0 (0)
Wound infection	25	1	. . .
Cholangitis	3	. . .	. . .
Urinary tract infection	16	1	. . .
Pneumonia	5	3	. . .
Bile leak	4	. . .	. . .
Gastrointestinal bleed	1	2	. . .
Myocardial infarction	2	. . .	. . .
Intra-abdominal abscess	8	3	. . .
Pulmonary embolism	1	. . .	. . .
Deep venous thrombosis	2	. . .	. . .
Line infection	5	. . .	. . .
Bacteremia	1	. . .	. . .
Arrythmia	2	. . .	. . .
Cerebrovascular accident	. . .	1	. . .
Splenic infarct	. . .	2	. . .
Clostridium difficile colitis	. . .	1	. . .
Patients without complications	306 (63)	144 (76)	33 (83)

**Data are presented as number (percentage) of complications. PD indicates pancreaticoduodenectomy; DP, distal pancreatectomy; TP, total pancreatectomy; and ellipses, not applicable.*

Table 4. Univariate Analysis of Influences on Length of Stay for PD*

Variable	Length of Stay, d	P
Period		<.001
Group 1 (4/90-6/95)	16.1 ± 0.6	
Group 2 (7/95-8/98)	12.2 ± 0.5	
Group 3 (9/98-3/00)	9.5 ± 0.4	
Pathologic diagnosis		.02
Pancreatic adenocarcinoma	12.1 ± 0.5	
Other 4 diagnoses	13.7 ± 0.4	
Case volume: correlation coefficient (*r*) = –0.73		<.001
Pylorus preservation		<.001
Non-pylorus-preserving PD	11.8 ± 0.3	
Pylorus-preserving PD	17.5 ± 0.7	
Fistula		<.001
Absence	12.3 ± 0.3	
Presence	19.4 ± 1.6	
Delayed gastric emptying		<.001
Absence	12.0 ± 0.3	
Presence	21.1 ± 1.1	
Any complication		<.001
Absence	10.5 ± 0.2	
Presence	17.4 ± 0.7	

**Data are presented as mean ± SEM. Univariate analysis using the* t *test or calculation of Pearson correlation coefficient (*r*). PD indicates pancreaticoduodenectomy.*

indicated that the important factors associated with decreasing LOS in PD were period of study, operative case volume, use of classic Whipple resection rather than pylorus-preserving PD, absence of pancreatic fistula, absence of delayed gastric emptying, and absence of other complications ($P<.001$ for all). **Figure 3** illustrates the correlation between operative case volume and decreasing LOS. When all potential predictors were included in the multiple linear regression model, period, operative case volume, use of pylorus-preserving PD, and presence of pancreatic fistula, delayed gastric emptying, or other complication remained independent predictors of LOS. These factors were significant at the $P<.05$ level.

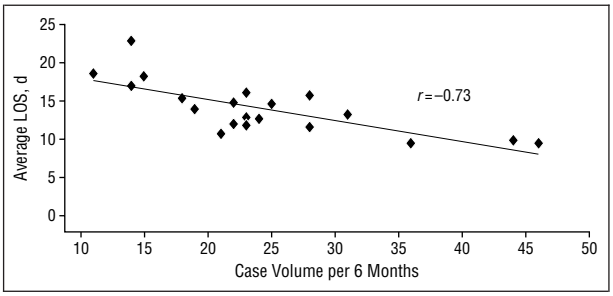

Figure 3. *Average length of stay (LOS) vs average 6-month case volume for pancreaticoduodenectomy at the Massachusetts General Hospital, Boston, from 1990 to 2000. Pearson correlation coefficient= – 0.73 (*P*<.001).*

COMMENT

These data indicate that in the last decade older patients are undergoing both PD and DP at our institution, and they support the notion that improvements in operative techniques and perioperative care have made pancreatic resection safer for a wide range of patients. In experienced centers, only the oldest patients with severe comorbidity are being denied pancreatic resection at this time.[4,31,32]

Clearly, fewer pancreatic resections are being performed for CP and more for cystic tumors. This phenomenon is partially explained by the fact that the use of abdominal computed tomography and ultrasound for unrelated conditions is producing more asymptomatic tumors.[14,33] Intraductal papillary mucinous tumors currently form an increasingly large proportion of cystic neoplasms referred to our institution (currently 17% of all pancreatic resections). These tumors are considered premalignant and are resected whenever possible.[34-36] The decline in proportion of resections done for CP may represent changes in referral patterns from gastroenterologists and primary care physicians, who are using extended courses of medical management and endoscopic interventions with pancreatic duct stenting in the treatment of CP.[37,38] However, pancreatic resection remains an important therapeutic tool in the treatment of selected patients with severe CP.[16-19]

Evolution of operative technique has also occurred at our institution in the past 10 years. Antrectomy with gastrojejunostomy is now used almost exclusively in lieu of pylorus-preserving PD. Our group has shown that in our hands, pylorus-preserving PD holds no advantage over classic Whipple resection in the treatment of CP with regard to the incidence of postoperative complications, nutritional status and glucose tolerance, and amount of pain relief.[16] Pylorus-preserving PD resulted only in higher rates of delayed gastric emptying and increased LOS.[16] In addition, spleen-sparing DP has been used with significantly greater frequency during the past 10 years. Splenic preservation is preferable because it eliminates the uncommon but poten-

tially fatal complication of overwhelming infection with encapsulated bacterial organisms. Spleen-sparing DP may also be preferable in the setting of a malignant neoplasm not directly involving the spleen because it is a putative mechanism for maintenance of immune surveillance.[25] We perform spleen-sparing DP in the resection of the pancreatic body and tail whenever anatomically feasible. In this series, only 2 patients developed a splenic infarct, and both were managed conservatively.

The rates of complications following resection essentially remained stable during the study period with the exception of delayed gastric emptying (for PD) and "other" complications (for PD and DP), which decreased significantly. We attribute this difference to enhanced expertise with operative techniques and decreasing use of pylorus-preserving PD. Mortality and rate of reoperation for PD remain low at 1% and 2%, respectively. Readmission rates did not change significantly for PD and DP, despite the implementation of clinical pathways in 1998.

Perhaps the most interesting improvement in outcome, and the focus of this article, is the decrease in LOS for PD during the last decade, from a mean of 16 days in the first 5 years to 9 days in the last 18 months. As expected, multivariate analysis shows that complication rates are among the strongest independent predictors of decreased LOS for PD. Specifically, pancreatic fistula, delayed gastric emptying, and other complications were powerful independent predictors of LOS. It seems intuitive that patients who experience more complications stay in the hospital longer; in their timely review of factors affecting LOS in PD, Brooks et al[27] showed that complications were independent predictors of increased postoperative and total LOS.

Increased case volume was also found to be an independent predictor of decreased LOS. Thus, these data support the notion that operative candidates should be given the choice of referral to centralized institutions performing a high volume of pancreatic resections. For PD, this strategy results in a lower rate of patient mortality,[39] and the medical literature indicates that this trend results in better outcomes and decreased costs.[6,7,10,12,40]

Interestingly, the use of pylorus-preserving PD was found to be a strong independent predictor of increased LOS. Our group has previously shown that LOS was longer for pylorus-preserving PD than for classic Whipple resection in CP, and this was presumed to be caused by increased rates of delayed gastric emptying.[16] We find and reaffirm that the adverse effect of pylorus-preserving PD is independent of other factors, including complications such as anastomotic leaks. Smaller studies have found no difference or slightly shorter LOS for this procedure.[18,41] The establishment of pylorus-preserving PD as an independent predictor of increased LOS may be partially influenced by our definition of delayed gastric emptying as failure to maintain oral intake by postoperative day 14; other large studies have variously defined this condition as failure to maintain oral intake after 7, 10, or 14 postoperative days.[42-44] We feel that our stringent definition is useful because it leaves very little diagnostic uncertainty with regard to the presence of delayed gastric emptying. Furthermore, we do not feel that this definition biased the multivariate analysis; when all patients with delayed gastric emptying are excluded, the median LOS for classic Whipple resections during the last 18 months is 8 days, and the median LOS for pylorus-preserving PD is 14 days. This suggests a genuine influence of operative technique on LOS, which may be explained at our institution by greater experience and comfort with the classic Whipple operation and consequent willingness to discharge those patients earlier. It is also our general practice to construct a retrocolic gastrojejunostomy, which appears to promote rapid return of gastric emptying and ability to eat, in most cases by 3 to 4 days. Most patients may be discharged from the hospital on a solid diet by postoperative day 8.

Finally, these results identify period as an important independent factor in predicting LOS. Although Figure 2 shows a gradual decline in LOS during the entire decade, we chose to examine the 3 periods that would accurately reflect the implementation of case management and clinical pathways. We feel that the relative stabilization and gradual decline in LOS after case management introduction in 1995, followed by the more pronounced decline in LOS after clinical pathway introduction in 1998, probably reflects 2 facts: (1) the combination of case management and clinical pathway use (after 1998) resulted in the most significant effect on LOS and (2) the decade witnessed the adoption of a more aggressive attitude toward the postoperative care of patients with PD in general. We would argue that the translation of this attitude into a tangible care strategy resulted in case management and clinical pathways. Taken as a whole, these data indicate that the implementation of case management and clinical pathways for patients undergoing pancreatic resection has had an identifiable effect on improving outcome (ie, decreasing LOS) while the rates of most complications have decreased or remained the same. Readmission rates did not change significantly, indicating that case management and clinical pathway introduction did not cause patient morbidity from overly aggressive discharge. The use of case management and clinical pathways has begun to improve outcomes in a variety of surgical environments,[28,30,45,46] and we have now demonstrated this benefit with a large series of pancreatic resections. The data of Brooks et al[27] identify later period as an independent predictor of LOS, and the authors state that this implies a "streamlining" of patient care as time goes on. Our data also demonstrate a convergence of the mean and median LOS during the past decade (Figure 2), signifying a reduction of the variance. Thus, case management and clinical pathways prove to be a validated strategy for better care; in reducing LOS, they may be important determinants of cost containment as well.[28,40,47]

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DISCUSSION

William Cioffi, MD, Providence, RI: It is a pleasure to have the opportunity to discuss this article presented by Dr Balcom on behalf of his colleagues, Drs Rattner, Fernandez-del Castillo, and Warshaw, from the Massachusetts General Hospital. He has reported on a consecutive series of 733 patients undergoing pancreatic resection over 1 decade. Nearly 500 of these underwent pancreaticoduodenectomy, and the other 190 had distal pancreatectomy; there were 40 total pancreatectomies and 14 middle-segment pancreatectomies.

They examined their data for length of stay, occurrence of complications, and mortality and then examined it for factors during the decade that made an impact on each of these variables. They found several things: One, they are performing more pancreatic resections today than they did 10 years ago; their rate has almost doubled. Two, they are operating on older patients, and despite this fact, their mortality rate has remained constant at a very respectable 1%. Next, their length of stay has decreased dramatically during the decade. They attribute their excellent results to their case volume, the decrease in use of pylorus preservation, and the initiation of both case management and clinical pathways.

Their results are in keeping with several other large series, most notably those reported by our guest, Dr Cameron, and his colleagues from Johns Hopkins as well as those from Memorial. I have several questions for Dr Balcom.

First, one of the major points in this article is that length of stay has decreased significantly during the decade. You point out that you believe case management and clinical pathways are either partially or wholly responsible for this fact. Please define for us how your case management system works and what the clinical pathway is that you have instituted. When I examined your length-of-stay data, it appeared that length of stay was decreasing prior to the institution of case management and clinical pathways. In 1995, the median length of stay was slightly more than 10 days, and that is when case management was instituted. In 1996 and 1997, the median length of stay was apparently 11 to 12 days, indicating to me that case management had little impact on length of stay. Clinical pathways were instituted in 1999, a time at which the median length of stay was approximately 9 days; at the end of the study period, in the year 2000, the median length of stay seems to have remained at 9 days. I would like you to comment on how you believe clinical pathways and case management have had an impact on length of stay.

Concerning your length-of-stay data, it is clear that a larger number of patients leave the hospital much sooner than they did a decade ago. Toward this end, you have fairly reported your readmission rates. For pancreaticoduodenectomy, the readmission rate is 11%, and for distal pancreatectomy, it has varied between 11% and 17% during the past 5 years. Does the length-of-stay data that you reported include the patient's length of stay from the readmission? If not, what impact does this have on your data? Could you comment on the reasons for readmission?

Another major point of your article is the decreased use of pylorus preservation. In the beginning of the series, you used this procedure approximately 45% of the time; by the end of the series, you were not performing it in any patients. I would assume that your reason for not using it now is your observation of increased delayed gastric emptying. However, other series, most notably those from Hopkins, report much higher use of pylorus preservation with a much decreased incidence of delayed gastric emptying. Could you comment on why you think delayed gastric emptying is such a prevalent problem in your hands?

One of the major reasons for your increased number of pancreatic resections involves a significant increase in the number of patients being operated on for cystic tumors of the pancreas. Dr Fernandez-del Castillo nicely outlined your approach to these patients, and I will not ask you more about that; however, at the same time you report an increased use of midsegment pancreatectomies as well as splenic salvage distal pancreatectomies. Could you define for us the criteria for the use of these procedures, and do you believe that splenic salvage distal pancreatectomy is actually a good oncologic procedure?

My final question has to do with quality of life following resection. The data you provided us are a short-term follow-up. Clearly, as we extend indications for pancreatic resection to a broader number of diseases, it is important that long-term quality of life be considered. Do you have any data on quality of life or functional outcome of your patients similar to what has been reported by other institutions? Of particular interest would be your decreased use of pylorus preservation, especially in patients with non–garden-variety adenocarcinoma. Do the patients receiving your standard resection have an increased incidence of alkaline reflux, gastritis, dumping syndrome, and the like?

In summary, this is an excellent series of patients undergoing pancreatic resection, with outstanding results. The mortality figures set a benchmark for any surgeon involved in the care of this type of patient. The authors have been extremely fair in the definition of complications, presenting a clear picture of the present-day morbidity and mortality rates of pancreatic resections. Dr Balcom and his colleagues should be congratulated for bringing to us such observations and for, once again, helping set benchmarks for the care of these patients.

Francis D. Moore, Jr, MD, Boston, Mass: Would Dr Balcom tell us of the fistula rate among these patients?

James Balcom, MD, Boston: Dr Cioffi first asked a question concerning the role of case management and clinical pathways in patient care. Very briefly, a case manager is an employee of the hospital who works closely with the nurses, physicians, physical therapists, and social workers to make patients comfortable while they are in the hospital and to provide them with a speedy discharge, whether it be to a rehabilitation facility or to home. In general, they ensure that the patient's care will be well coordinated. Our clinical pathway currently outlines a 7- to 8-day postoperative course after Whipple resection. It is basically a set of standardized orders that detail postoperative milestones; for example, our pathway calls for removal of the nasogastric tube on postoperative day 1 or 2, and removal of the closed-suction drains on postoperative days 5 and 6.

Dr Cioffi also pointed out that the median and mean length of stay were decreasing prior to the institution of case management and in fact were close to the length of stay during the second period. That is true. We feel that the stabilization of length of stay after case management introduction may reflect an adjustment period that culminated with the introduction of clinical pathways in September 1998. Clearly, the combination of case management and clinical pathways seems to bring the median length of stay down to 8 days during the last period, and that is where we stand now. Half of our patients are going home by postoperative day 8. The gradual decline in the length of stay during the last half of the decade may also reflect increasingly aggressive attitudes toward prudent postoperative care and discharge.

Dr Cioffi asked several questions concerning readmission rates. Of importance, we found that the readmission rate did not change significantly over time for pancreaticoduodenectomy or distal pancreatectomy. We analyzed readmission rate as a separate variable and did not include readmission hospitalization days in the calculation of length of stay. It is difficult to say exactly what impact this has had on our data. I suspect that because most readmission hospitalizations were short and because they were rather evenly distributed across the decade, as evidenced by the stable readmission rate, the separate analyses have had little impact on the data. Most readmissions were for mild dehydration and general "failure to thrive." Wound infection with associated cellulitis was the second most common reason for readmission. Rare causes included intra-abdominal abscess and gastrointestinal bleeding.

The next question had to do with pylorus preservation. As the data show, we are doing a lot less of these. In fact, we did not do any in the last 130 resections. In our hands, at least, the incidence of delayed gastric emptying seems higher, and patients stay in the hospital longer as a consequence of having this operation. Our experience is that the classic Whipple resection enables patients to have a very rapid return of gastrointestinal function. Most of them are eating by 3 to 4 days after the operation, and again, most of them are home after 8 days.

With regard to the use of spleen-sparing operations, a decision about splenic preservation must be highly individualized. An example of a patient who would be a good candidate for splenic preservation is someone with a small cystic tumor in the body or tail of the pancreas that is thought to be a serous cystadenoma or benign mucinous cystic neoplasm. There is a very low incidence of encountering a malignant situation in that setting. Certainly, any patient who has a very large tumor, a tumor invading the splenic hilum, or a tumor associated with extensive lymphadenopathy in the splenic hilum is probably not a candidate for a spleen-sparing operation, and the spleen should be resected. Somewhat similar indications exist for the middle-segment pancreatectomy. Small, benign-appearing tumors in the pancreatic neck or body are candidates for the middle-segment operation. Intraoperative resection margins may be helpful in guiding the decision to undertake a more extensive resection.

We do not currently have any data in this series on the quality of life after resection although other series have examined this issue. One recent series from our institution showed no difference in outcomes such as pain control, insulin use, and body mass index in patients with chronic pancreatitis who underwent pylorus-preserving pancreaticoduodenectomy vs classic Whipple resection. Perhaps in a future study we could examine long-term quality-of-life indices in these 733 patients.

With regard to the treatment of pancreatic fistula, Dr Moore, we are seeing a relatively constant rate of fistula throughout the past decade. However, it has become clear that the vast majority of these fistulae are fairly benign, and unless they are high-output fistulae, they are often managed with progressive drain retraction for 3 to 4 days, even up to a week. Many times this can be done as an outpatient. Eventually the drainage decreases, and the drain can be discontinued. We have experienced some morbidity in the form of intra-abdominal abscesses and at least 1 mortality in our series, but clearly these complications are very rare.