

Blumgart anastomosis for pancreaticojejunostomy minimizes severe complications after pancreatic head resection

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Background: Leakage from the pancreaticojejunostomy is the major cause of septic complications after partial pancreaticoduodenectomy. This study evaluated a new transpancreatic U-suture technique (Blumgart anastomosis, BA), which aims to avoid shear forces during knot-tying.

Methods: Using a before–after study design, BA was compared with a modified Cattell–Warren anastomosis (CWA). Two patient cohorts (CWA, 90; BA, 92), which were similar with respect to primary diagnosis, age, sex and American Society of Anesthesiologists score, were compared retrospectively. Dependent variables were surgical and overall morbidity and mortality after partial pancreaticoduodenectomy.

Results: Duration of operation (354 versus 328 min for CWA versus BA; $P = 0.002$), pancreatic leakage rate (13 versus 4 per cent; $P = 0.032$), postoperative haemorrhage (11 versus 3 per cent; $P = 0.040$), total surgical complications (31 versus 15 per cent; $P = 0.011$), general complications (36 versus 17 per cent; $P = 0.005$) and length of intensive care unit stay (median 5.4 versus 2.8 days; $P = 0.015$) were significantly reduced after BA. These effects were not related merely to an improvement over time.

Conclusion: BA appears to be a fast, simple and safe technique for pancreaticojejunostomy. It might reduce leakage rates and surgical complications after partial pancreaticoduodenectomy.

Presented in part to the 94th Annual Meeting of the Vereinigung Mittelrheinischer Chirurgen, Bonn, Germany, September 2006, and to the 124th Annual Meeting of the Deutsche Gesellschaft für Chirurgie, Munich, Germany, May 2007

Paper accepted 25 February 2009

Published online in Wiley InterScience (www.bjs.co.uk). DOI: 10.1002/bjs.6634

Introduction

Partial pancreaticoduodenectomy remains a complex and technically demanding operation. The classical Kausch–Whipple procedure^{1,2} and its pylorus-preserving modification by Traverso and Longmire³ are established procedures for resectable cancer of the pancreatic head, and for other benign and malignant diseases of the peripapillary region. In recent decades, advances in surgical technique and perioperative management have dramatically reduced the postoperative mortality rate after pancreatic head resection^{4–9}. However, even in high-volume centres the postoperative morbidity rate remains as high as 30–50 per cent^{4,6–12}.

Treatment of the pancreatic stump is the major problem during the reconstructive phase of partial pancreatoduodenectomy^{13,14}. Ligation of the pancreatic stump and duct occlusion by rubber glue has largely been

abandoned because it is associated with a high rate of postoperative fistula and exocrine gland dysfunction^{15–17}. It is now common practice to perform a pancreaticoenteric anastomosis, using the jejunum or stomach for drainage of the pancreatic juice^{18–20}. Pancreaticojejunostomy appears to be performed most widely^{21,22}, but probably carries the highest risk of failure of all abdominal anastomoses. Leakage of the pancreaticojejunostomy, with subsequent fistula, abscess formation, sepsis or bleeding remains the single most important source of morbidity and death after pancreaticoduodenectomy²³. To prevent this complication, several prophylactic pharmacological approaches, as well as various surgical techniques and modifications of pancreaticoenteric reconstruction, have been proposed²⁴. However, pancreatic fistula may be inevitable, even in experienced hands. Many large studies have published pancreatic fistula rates of more than 10 per cent, and some of up to 20 per cent^{4,6–8,10–12,18–20,23–26}.

In 2003, a new standardized U-suture technique for pancreaticojejunostomy was introduced at Klinikum Grosshadern, University of Munich, to minimize postoperative pancreatic leakage. The technique was originally devised by L. H. Blumgart at Memorial Sloan–Kettering Cancer Center, New York, but its clinical results have not yet been published. In the present study, this U-suture technique was termed the Blumgart anastomosis (BA)²⁷. In January 2003, the widely used Cattell–Warren duct-to-mucosa anastomosis (CWA) for partial pancreaticoduodenectomy was abandoned at this institution and replaced by the BA. The present retrospective study compared BA with CWA with respect to anastomotic leakage, postoperative morbidity and mortality.

Methods

From January 1998 all patients who had a pancreaticoduodenectomy at the Department of Surgery, Klinikum Grosshadern, University of Munich, were entered into a prospective database. This included 248 patients up to December 2005. Standard partial pancreaticoduodenectomy was performed in 182 patients, and other surgical procedures in the remainder. Before 2003 the pancreaticojejunostomy was performed exclusively as a modified CWA²⁸, whereas the BA was used as the sole method of reconstruction after 1 January 2003²⁷. Using a before–after cohort study design, all 182 patients who had partial pancreaticoduodenectomy were included in a retrospective comparison of BA and CWA with respect to the intraoperative and postoperative course.

Surgical technique

All surgical procedures were performed by or under the supervision of one of three experienced senior pancreatic surgeons. Initial surgical steps included a partial pancreaticoduodenectomy, completion of the lymphadenectomy if appropriate, and mobilization of the cut end of the left hemipancreas for approximately 1.5 cm. Subsequently the intestinal reconstruction was always started with retrocolic placement of the first jejunal loop to construct the pancreaticoenteric anastomosis. The end-to-side pancreaticojejunostomy, performed by one of the two methods, was followed by a bilioenteric end-to-side anastomosis 5–7 cm distal to the pancreatic anastomosis, and by a subsequent antecolic end-to-side gastrojejunostomy or pylorojejunostomy, depending on the type of resection (with or without preservation of the pylorus). If the pylorus was not preserved a Braun anastomosis was constructed. In accordance

with institutional standards, pylorus-preserving procedures were performed only in patients with chronic pancreatitis, adenoma of the papilla and in some rare instances of early-stage ampullary cancer. The pylorus-preserving procedure became the institutional standard for periampullary tumours only after 2005 (beyond the present study period).

At the end of the procedure, two drains were placed ventral and dorsal to the pancreaticojejunostomy. Neither stenting of the pancreatic duct nor external or internal drainage of the pancreatic juice was performed. Prophylactic cefuroxime was administered as a perioperative single shot. Octreotide was not used routinely, but was prescribed if the surgeon felt that the pancreatic stump was very soft (100 µg subcutaneously three times daily for 5 days). Oral fluids (water, tea) were started 6 h after surgery and the nasogastric tube was removed on day 2. All abdominal drains were removed on day 4 after surgery if the drainage fluid was clear, did not exceed 250 ml per 24 h and the amylase level was less than three times the serum level. Pain medication was applied by epidural catheter for 5 days and oral nutrition was started on day 5 if contrast radiography of the gastrojejunostomy or pylorojejunostomy was normal.

Cattell–Warren pancreaticojejunostomy

After a small incision had been made at the antimesenteric side of the jejunal loop, a modified CWA was performed (Fig. 1). Monofilament absorbable interrupted sutures (MaxonTM 5/0; Syneture, Covidien, Neustadt, Germany) were placed with an atraumatic needle, starting at the posterior surface of the pancreas. The dorsal capsule of the pancreas was sutured to the seromuscular layer of the jejunum. After completion of the dorsal part of the anastomosis, the central part of the anastomosis was performed as a duct-to-mucosa anastomosis using MaxonTM 5/0 interrupted sutures. Finally, the ventral part of the anastomosis was sutured in the same fashion.

Blumgart anastomosis

Four transpancreatic U-sutures were placed straight through the pancreatic remnant about 1 cm distal from the cut end (MaxonTM 4/0, MH1 needle; Syneture). Each of the sutures started at the ventral side of the gland, going from front to back straight through the pancreas. This stitch was followed by a seromuscular stitch through the back wall of the jejunal loop, coming back through the pancreas from back to front (Fig. 2a,b), thereby approximating the jejunum to the dorsal face of the pancreatic remnant. Each of the U-sutures was placed at a distance of 5–10 mm from the next. Two of each were placed cranial and two of each caudal to

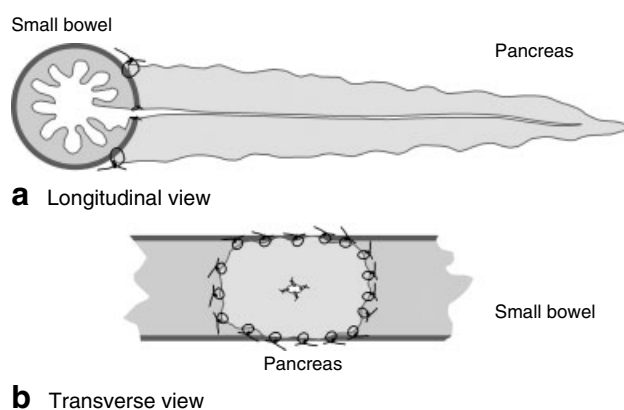


Fig. 1 Modified Cattell–Warren anastomosis: **a** longitudinal and **b** transverse views. Multiple sutures placed tangentially through the pancreatic capsule might induce shear forces and pancreatic microleakage during tying of the knots

the pancreatic duct, which was protected by a blunt-tipped probe of adequate size. The needles of these transpancreatic sutures were retained and the sutures organized for later completion. After incision of the jejunum at the antimesenteric side, a duct-to-mucosa anastomosis was constructed using MaxonTM 5/0 interrupted sutures (Fig. 2c). Finally, the U-sutures were completed by placing both needles through the anterior portion of the jejunum, adapting the jejunum to the pancreas and tying the knots carefully at the ventral wall of the jejunum (Fig. 2d,e). The pancreatic remnant was now completely covered by jejunal serosa and the sutures were protected from cutting through the pancreatic parenchyma by the jejunal wall (Fig. 2e,f).

Data collection

Retrospective data analysis was approved by the local institutional review board. The following information was collected for each patient: age, sex, primary diagnosis, diagnosis-related symptoms, surgical history, medical history, American Society of Anesthesiologists (ASA) score, laboratory values before surgery (serum glutamic oxaloacetic transaminase, bilirubin, alkaline phosphatases, albumin, creatinine, lipase, haemoglobin, white cell count, C-reactive protein, partial thromboplastin time and international normalized ratio), type of surgery (with or without pylorus preservation), intraoperative blood loss, transfusion requirements, octreotide prophylaxis, duration of the surgical procedure, number and type of postoperative surgical (local) and general (systemic) complications, number of relaparotomies and reasons for them, length of stay in the intensive care unit (ICU) and

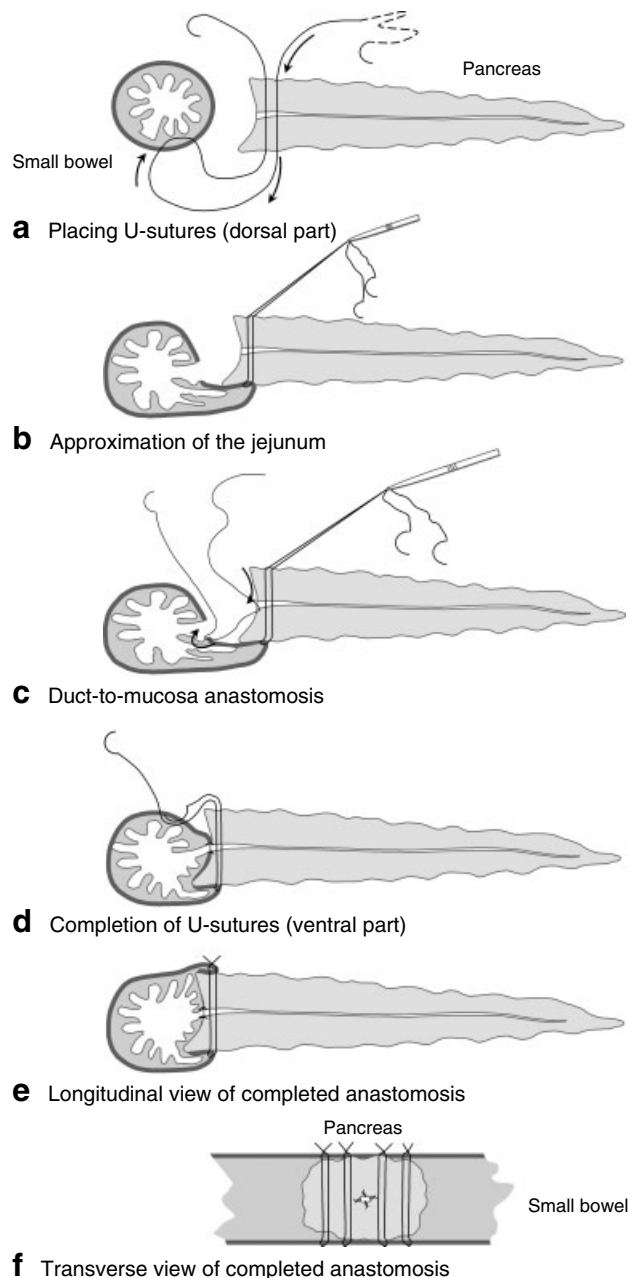


Fig. 2 Blumgart anastomosis: **a–e** longitudinal and **f** transverse views. The transpancreatic U-suture technique reduces the total number of stitches and minimizes tangential shear forces of sutures at the cut end of the pancreatic remnant. The ventral and dorsal walls of the jejunum should prevent sutures from cutting through the pancreatic parenchyma when the knots are tightened

in hospital, and hospital mortality. All data were entered into a separate Microsoft[®] FileMaker database for further analysis (Microsoft Corporation, Seattle, Washington, USA).

Definition of complications

Postoperative morbidity was defined as any postoperative surgical (local) or general (systemic) complication. Pancreatic leakage was defined as a clinically relevant pancreatic fistula grade B or C, according to the International Study Group on Pancreatic Fistula²⁵. Such fistulas were defined by measurable pancreatic fluid output after postoperative day 3 (containing more than three times the normal serum amylase level) with clinical signs of an infection and/or necessitating a change in clinical management. Biliary leakage was defined as any biliary output via percutaneous drains after the first postoperative day, or detected at a reoperation. Postoperative bleeding was defined as a postpancreatectomy haemorrhage grade B or C, according to the International Study Group of Pancreatic Surgery²⁹. This included all early and late postoperative gastrointestinal and intra-abdominal bleeds with immediate therapeutic consequences (for example blood or fluid transfusions, endoscopy, angiography or relaparotomy). Acute pancreatitis was defined chemically as a raised serum amylase and/or lipase level (at least threefold above the normal level) for at least 3 consecutive days after postoperative day 3. Acute pancreatitis was confirmed by computed tomography (CT). Intra-abdominal fluid collection or abscess was defined as any collection of fluid, bile or pus (with or without clinical significance) that measured at least 5 cm in diameter on CT or ultrasonography after postoperative day 3. Moreover, no persistent leakage of biliary or pancreatic fluid was seen if drainage of the collection was needed. Deep wound infection was defined as a purulent discharge from the wound requiring surgical irrigation, vacuum-assisted wound closure and/or reoperation (including fascial dehiscence). Respiratory events included postoperative pneumonia defined according to Lowenkron and Niederman³⁰, pleural effusion, acute respiratory distress syndrome and pulmonary embolism. Cardiac events were defined as acute coronary syndromes, cardiac arrhythmia, low cardiac output or cardiac arrest. Other infections comprised all urinary, gastrointestinal, catheter-associated or superficial wound infections.

Statistical analysis

Continuous data are presented as median (range), and were analysed by means of the Mann–Whitney *U* test. Categorical variables were compared using χ^2 or Fisher's exact test, as appropriate. $P \leq 0.050$ in a two-tailed test was considered statistically significant. Risk factors for major local and systemic complications after pancreatic head resection were identified by univariable and multivariable

analysis. Variables found to be associated with systemic or major local complications in the univariable analysis ($P < 0.200$) were entered into a stepwise logistic regression model for multivariable analysis of risk factors. All statistical analyses were performed using SAS[®] version 9.1.3 (SAS Institute, Cary, North Carolina, USA).

Results

The study included 182 patients, 90 in the CWA and 92 in the BA group. The groups were similar with regard to demographics, surgical history and medical risk, except for a higher frequency of cardiopulmonary disease in the BA group (*Table 1*). There were no differences in preoperative laboratory values between the groups. The ASA score did not fluctuate over the study period (1998–2005) (*Fig. 3a*). Of the 182 pancreaticoduodenectomies, 160 (87.9 per cent) were performed for malignant tumours of the duodenopancreatic region and 22 (12.1 per cent) for benign indications (*Table 2*). The frequency of malignant disease was comparable between the groups.

Intraoperative course

The CWA and BA groups were comparable with respect to the surgical procedure (*Table 2*). Most patients had a classical Kausch–Whipple operation for malignancy; only

Table 1 Patient characteristics

	Cattell–Warren anastomosis (<i>n</i> = 90)	Blumgart anastomosis (<i>n</i> = 92)	<i>P</i> §
Age (years)*	65.0 (21–78)	66.5 (23–82)	0.065¶
Sex ratio (M:F)	53:37	52:40	0.747
Symptoms			
Jaundice	47 (52)	44 (48)	0.553
Pain	17 (19)	23 (25)	0.320
Previous interventions			
Biliary stent (before surgery)	52 (58)	48 (52)	0.447
Cholecystectomy	10 (11)	17 (18)	0.162
Major abdominal surgery†	16 (19)	24 (26)	0.176
Medical risk			
ASA score*	2.0 (1–3)	2.0 (1–4)	0.971¶
Cardiopulmonary disease‡	31 (34)	46 (50)	0.034
Diabetes	19 (21)	24 (26)	0.429
Alcohol abuse	4 (4)	3 (3)	0.719#

Values in parentheses are percentages unless indicated otherwise; *values are median (range). †Surgery to the stomach, liver, kidney or colon. ‡Coronary heart disease, history of myocardial infarction, congestive heart failure, valvular heart disease, chronic obstructive lung disease, emphysema and hypertension. ASA, American Society of Anesthesiologists. § χ^2 test unless indicated otherwise; ¶Mann–Whitney *U* test, #Fisher's exact test.

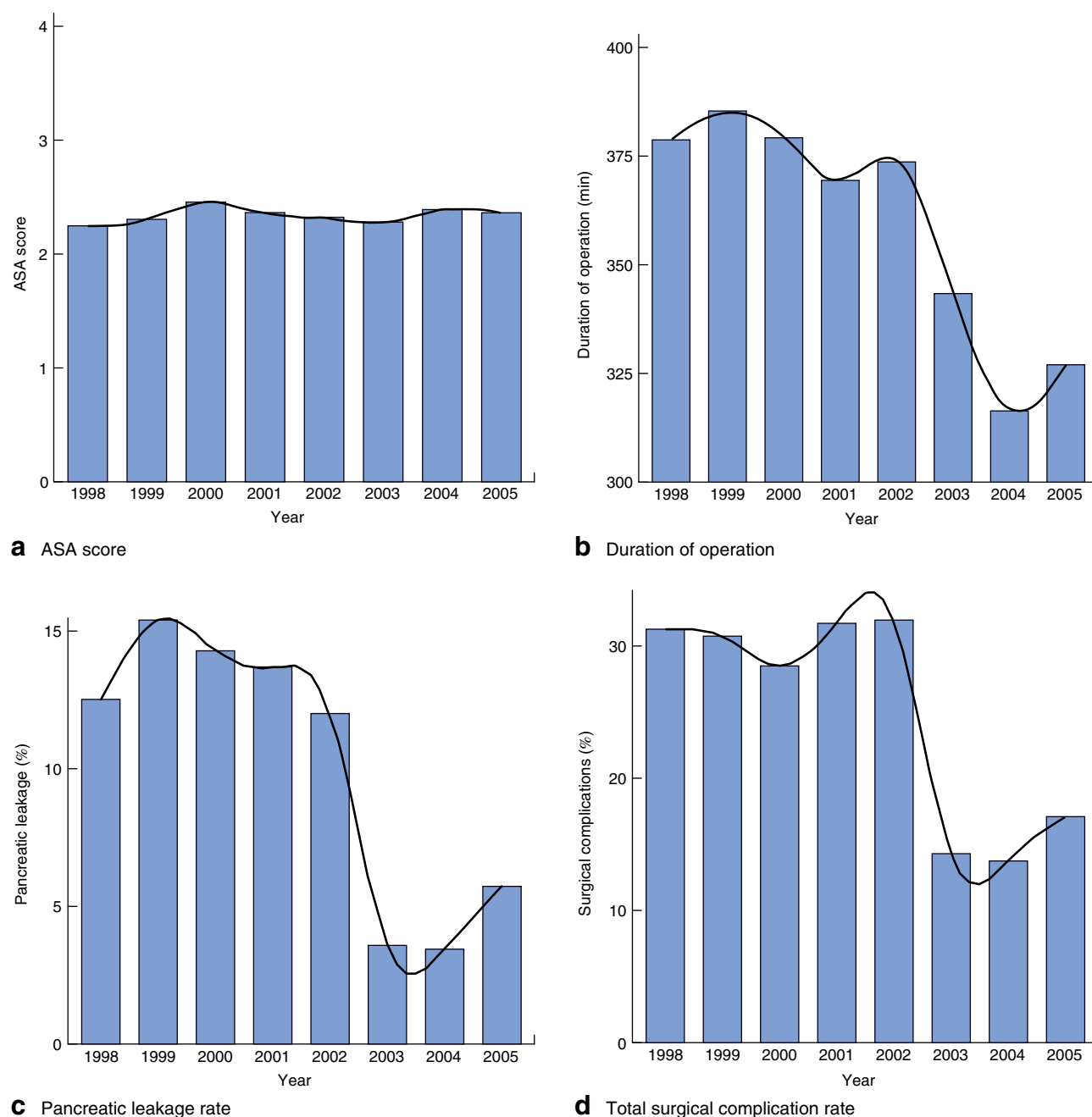


Fig. 3 Changes during the study period in **a** American Society of Anesthesiologists (ASA) score, **b** duration of operation, **c** pancreatic leakage rate and **d** total surgical complication rate

14.8 per cent of patients had a pylorus-preserving operation for benign disease or early ampullary cancer. All partial pancreaticoduodenectomies were elective procedures. A quarter of patients in each group received perioperative octreotide prophylaxis (*Table 2*). There were no significant

differences between groups in estimated intraoperative blood loss and transfusion requirements. The median duration of operation was significantly less in the BA group (*Table 2*). A stepwise decline in the duration of operation was noted after the introduction of BA in 2003 (*Fig. 3b*).

Table 2 Diagnosis and operative data

	Cattell–Warren anastomosis (n = 90)	Blumgart anastomosis (n = 92)	P§
Diagnosis			
Malignancy	82 (91)	78 (85)	0.190
Pancreatic cancer	65 (72)	47 (51)	0.003
Ampullary cancer	14 (16)	13 (14)	0.787
Other (e.g. bile duct cancer)	3 (3)	18 (20)	0.001
Adenoma of the papilla	0 (0)	3 (3)	0.246¶
Chronic pancreatitis	8 (9)	11 (12)	0.499
Operative procedure			
Kausch–Whipple	80 (89)	75 (82)	0.162
Traverso–Longmire	10 (11)	17 (18)	0.162
Intraoperative variables			
Patients requiring transfusion†	44 (49)	43 (47)	0.772
Estimated blood loss (ml)*	1150 (100–8000)	900 (200–6500)	0.106#
Duration of operation (min)*	354 (150–780)	328 (150–675)	0.002#
Patients receiving octreotide‡	20 (22)	25 (27)	0.439

Values in parentheses are percentages unless indicated otherwise; *values are median (range). †During operation and in the recovery room.

‡During operation and for 5 days afterwards. § χ^2 test unless indicated otherwise; ¶Fisher's exact test; #Mann–Whitney *U* test.

Postoperative complications

Types and frequency of postoperative complications are shown in *Table 3*. Significant differences between groups were found for pancreatic leakage and postoperative haemorrhage, both complications being significantly less frequent in the BA cohort. The pancreatic leakage rate and rate of total surgical complications both improved abruptly after the introduction of BA in 2003 (*Fig. 3c,d*). With the exception of postoperative cardiac events, which were slightly more frequent in the BA group, non-surgical complications were more common in the CWA cohort (*Table 3*).

The total postoperative morbidity rate was lower after BA than CWA (28 *versus* 48 per cent; $P = 0.007$). Postoperative length of stay in the ICU was significantly shorter after BA than CWA (2.8 (0–52) *versus* 5.4 (0–62) days; $P = 0.015$), whereas the total hospital stay was comparable (15 (7–101) *versus* 18 (7–83) days respectively; $P = 0.412$). The hospital mortality rate tended to be lower when BA was performed (3 *versus* 8 per cent; $P = 0.210$).

Risk analysis

Results of risk analysis for major local and systemic complications after pancreaticoduodenectomy are summarized

Table 3 Postoperative complications

	Cattell–Warren anastomosis (n = 90)	Blumgart anastomosis (n = 92)	P¶¶
Surgical complications*	28 (31)	14 (15)	0.011##
Pancreatic leakage†	12 (13)	4 (4)	0.032
Biliary leakage‡	6 (7)	3 (3)	0.327
Postoperative haemorrhage§	10 (11)	3 (3)	0.040
Acute pancreatitis¶	2 (2)	4 (4)	0.682
Intra-abdominal fluid collection or abscess#	9 (10)	4 (4)	0.139
Deep wound infection**	8 (9)	5 (5)	0.366
Reoperation	13 (14)	6 (7)	0.081##
Non-surgical complications*	32 (36)	16 (17)	0.005##
Respiratory events††	19 (21)	4 (4)	0.001
Cardiac events‡‡	8 (9)	11 (12)	0.499##
Renal failure	6 (7)	0 (0)	0.013
Liver failure	7 (8)	3 (3)	0.210
MODS	5 (6)	0 (0)	0.028
Infections of other origin§§	24 (27)	4 (4)	< 0.001
Total surgical and non-surgical complications*	43 (48)	26 (28)	0.007##

Values in parentheses are percentages. *Some patients had more than one complication. †Clinically relevant pancreatic fistula grade B or C²⁵. ‡Any biliary output via percutaneous drains after postoperative day 1.

§Clinically relevant haemorrhage grade B or C²⁹. ¶Raised serum amylase and/or lipase level (at least threefold above the normal level) for at least 3 consecutive days after postoperative day 3. Acute pancreatitis was confirmed by computed tomography. #Any collection larger than 5 cm after postoperative day 3. **Need for surgical irrigation, vacuum-assisted closure or reoperation. ††Including pneumonia³⁰, pleural effusion, acute respiratory distress syndrome and pulmonary embolism. ‡‡Including acute coronary syndromes, arrhythmia, low cardiac output and cardiac arrest. §§Including urinary, gastrointestinal, catheter-associated and superficial wound infections. MODS, multiple organ dysfunction syndrome. ¶¶Fisher's exact test unless indicated otherwise; ## χ^2 test.

in *Table 4*. A major local complication endpoint was reached if one or more of the following complications were present: pancreatic leakage (grade B or C pancreatic fistula), biliary leakage or postoperative bleeding (grade B or C postpancreatectomy haemorrhage)^{25,29}. For this analysis, a postoperative systemic complication was defined as any organ dysfunction related to an infection. Neither putative general risk factors, such as age, sex or ASA score, nor specific surgical parameters, such as duration of operation, intraoperative blood loss or

Table 4 Predictors of a complicated postoperative course

	Major local complications*		Systemic complications†	
	Univariable <i>P</i>	Multivariable <i>P</i> ‡	Univariable <i>P</i>	Multivariable <i>P</i> ‡
Medical risk factors				
Age	0.446	—	0.773	—
Sex	0.584	—	0.368	—
ASA score	0.281	—	0.296	—
Surgical risk factors				
Use of octreotide	0.572	—	0.959	—
Blood loss	0.104	0.230	0.155	0.327
Duration of operation	0.198	0.426	0.041	0.093
Type of anastomosis (CWA <i>versus</i> BA)	0.006	0.038	<0.001	0.001

*Pancreatic leakage, biliary leakage and postoperative bleeding. †Organ dysfunction related to an infection (for example cardiopulmonary, renal, urinary, gastrointestinal and catheter associated). ASA, American Society of Anesthesiologists; CWA, Cattell–Warren anastomosis; BA, Blumgart anastomosis.

‡Multivariable analysis was performed if univariable testing revealed $P < 0.200$.

use of octreotide, were independent predictors of postoperative complications. The only independent risk factor for a major local or systemic postoperative complication was the type of anastomosis used for pancreaticojejunostomy.

Discussion

Pancreaticenteric reconstruction is difficult for two reasons. First, the anastomosis is constructed to connect a solid organ to a hollow abdominal viscus and, second, the pancreatic juice might interfere with the proper sealing and healing of the anastomosis. Based on the present results, BA appears to be a fast, simple and safe technique for pancreaticojejunostomy. The frequency of total surgical complications and specific surgical key complications, such as pancreatic leakage and postoperative bleeding, was significantly lower after BA than CWA pancreaticojejunostomy.

Several previous studies examined perioperative and intraoperative risk factors for anastomotic failure. Age, prolonged jaundice, creatinine clearance and intraoperative blood loss were identified as perioperative risk factors for anastomotic leakage³¹. In the present population these potential risk factors were similarly distributed in the two groups.

Texture of the pancreatic stump, pancreatic duct size and the output of pancreatic juice have also been reported to correlate with postoperative leakage. The quality of such morphological and functional characteristics is known to depend on the underlying disease^{32–35}. Firmer glands and dilated ducts, as occur in chronic pancreatitis, are technically easier to anastomose and are therefore associated with fewer postoperative complications. As the proportion of patients with chronic pancreatitis was

comparable in the present study groups, this is unlikely to be responsible for the better results obtained with the BA procedure.

Pancreatic cancer, which is more likely to induce duct dilatation and fibrosis than bile duct cancer or papillary adenoma, was less common in the BA cohort, whereas more patients in this group had bile duct cancer, which has been associated with a higher leakage rate after pancreaticoduodenectomy³⁶. The proportion of patients with ampullary cancer was comparable between groups. Therefore, an unequal distribution of primary diagnoses is not likely to explain the significant improvement in leakage rate and surgical complications after BA.

It should be noted that only clinically relevant complications were included in the outcome analyses, such as grade B or C pancreatic fistulas and grade B or C postoperative haemorrhage. Complications were defined based on international consensus^{25,29}, thereby allowing future comparison of the present results with those of other studies.

Data regarding the use of intraluminal drains and pancreatic duct stents are conflicting. External drainage of the pancreatic juice is still common³⁷, and some clinical and experimental data have shown that the patency of the pancreaticointestinal anastomosis might be improved by using ductal stents^{38,39}. However, because these have not been consistent findings^{37,39–41}, and pancreatic duct drainage may cause acute postoperative pancreatitis of the pancreatic stump, intraluminal tubes and ductal stents were not applied during pancreaticoduodenectomy in the present study.

Octreotide has been anticipated to reduce pancreatic leakage. A meta-analysis of ten randomized controlled trials has shown that only one in nine patients (11 per cent) may benefit from octreotide treatment with respect to

pancreas-specific complications⁴². Approximately a quarter of patients received perioperative octreotide prophylaxis in the present study, but the use of octreotide did not differ between study groups.

A meticulous anastomosis based on a sound surgical technique is the key factor in preventing anastomotic leakage after pancreaticoduodenectomy. Several methods have been published, and various studies have compared end-to-end with end-to-side anastomosis, dunking with duct-to-mucosa techniques, and pancreaticojejunostomy with pancreaticogastrostomy^{18,22,24,43,44}. Nearly all of the published techniques have one potential risk in common: the sutures through the pancreatic remnant are placed tangentially through the capsule and may therefore develop shear forces at the fragile pancreatic parenchyma. It is particularly during knot-tying that sutures may cut through the pancreas. The BA aims to avoid this problem as it combines a duct-to-mucosa anastomosis with four transpancreatic U-sutures that are free from tangential tension and shear forces. It is thereby possible to cover the pancreatic cut end completely with jejunal serosa and protect the knots from cutting through the pancreatic tissue.

A similar technique was published recently by Langrehr and colleagues⁴⁵, who combined an end-to-side dunking anastomosis with transpancreatic U-sutures; they compared this 'mattress technique' with the traditional CWA²⁸. Although the mattress anastomosis was significantly quicker to construct than the CWA, no major clinical effects were noted. However, the frequency of pancreatic leakage (3.5 per cent), surgical complications (31.6 per cent) and reoperations (8.8 per cent) was low in the mattress group, and lower than in similar patient cohorts described by others^{19,44,46}. Complication rates in the Langrehr study were comparable to those in the present study. These findings may corroborate the hypothesis that use of U-sutures for pancreaticojejunostomy may reduce surgical complications.

Another approach to the prevention of shear forces at the pancreatic remnant was published by Peng and co-workers⁴⁷, who performed a complex three-layer dunking anastomosis ('binding anastomosis'), in which chemical burn of the mucosa and two layers of suturing were followed by a circular ligature around the entire circumference of the anastomosis to balance differences in diameter between the jejunum and pancreatic remnant. Pancreatic leakage rates of 0 per cent have been reported repeatedly using this technique⁴⁷⁻⁴⁹. However, binding pancreaticojejunostomy appears to be technically demanding, and these exceptional results may also depend on the definition of pancreatic leakage and fistula.

Year-by-year analysis of the pancreatic leakage and surgical complication rates demonstrated a fairly stable period in which the CWA technique was in use and a steep decrease after the introduction of the BA method in 2003. These results argue against a mere improvement over time owing to a continuous learning curve and increased experience with pancreatic surgery in general.

Non-surgical complications were significantly less common in the BA group, with the exception of cardiac events, which occurred at a slightly higher rate in this cohort. This might be explained by changes in patient selection over time, in particular an increase in operations in patients with cardiopulmonary risk. However, the general preoperative risk profile was similar in both groups of patients and, in particular, the preoperative ASA score was constant during the 8-year study. It is a common observation that a lower surgical complication rate is associated with fewer non-surgical complications. Nevertheless, the retrospective nature of this study did not allow adjustment for changes in organization and process of care over the years. It cannot be ruled out that such changes also had an effect on the non-surgical complication rate.

To corroborate the outcome results, a multivariable analysis of several potential risk factors was performed. This revealed that the type of anastomosis was the only independent predictor of postoperative outcome. Use of the classical duct-to-mucosa anastomosis was the only risk factor associated with a higher rate of local and systemic complications after partial pancreaticojejunostomy. These results clearly emphasize the importance of a safe pancreaticojejunostomy in relation to other medical and surgical risk factors.

The present study has a number of limitations. First, there are limits to the generalizability of the data because they were analysed retrospectively, and represent the experience of a single centre with its unique case mix, surgical standard, organization and process of care. Second, a key role for outcome determination must be attributed to improvements in healthcare and organization over time. Although surgical standards unrelated to the type of anastomosis remained principally unchanged over the 8 years, some other aspects of perioperative management may have changed. An effect of such potential confounders cannot be excluded completely. However, it is unlikely that non-surgical improvements in perioperative healthcare were of equal importance to the frequency of specific major surgical complications such as pancreatic leakage or postoperative bleeding.

Within the limitations of this retrospective before-after study, BA appears to be a fast, simple and safe technique for pancreaticojejunostomy. Compared with conventional

procedures this technique reduced leakage rates and other complications after pancreaticojejunostomy.

Acknowledgements

The authors thank M. M. Heiss (Department of Surgery, Merheim Medical Centre Cologne, University of Witten-Herdecke) for establishing BA at the Department of Surgery, Klinikum Grosshadern, University of Munich. Many thanks also to W. H. Hartl (Department of Surgery, Grosshadern Campus) for data management, statistical analysis and critical revision of the manuscript, and M. Roth (Medical School, University of Munich) for data acquisition and analysis. The authors are grateful to the following colleagues, who were involved in the surgical management of patients included in the study: M. K. Angele, C. Graeb, F. Löhe and W. E. Thasler (all Department of Surgery, Klinikum Grosshadern). The authors declare no conflict of interest.

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