How to Pass on Expertise: Pancreatoduodenectomy at a Teaching Hospital

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Abstract. Pancreatoduodenectomy (PD) has become a routine procedure. Recent series report perioperative mortality rates of 5% or less, moderate morbidity, and even improved long-term survival. Nevertheless, being one of the most complex abdominal operations, a certain number of surgical procedures (i.e., personal caseload) seems essential for acceptable results. The objectives of this retrospective study were to evaluate whether PD can be safely performed as a teaching operation, and if the personal caseload of the senior surgeon affects morbidity and mortality. A series of 128 consecutive PDs carried out at a large academic teaching hospital were analyzed. The 49 operations performed by 11 residents of the surgical department as teaching operations under supervision of an experienced (senior) surgeon (ES) were compared with operations performed by an ES (group 2, n = 79). Three patients died from non-procedure-related causes (two in group 1). Eleven patients of group 2 had to be reoperated, in contrast to three in group 1 (NS). The total number of complications and number of pancreatic fistulas were comparable in the two groups. Surgeons performing less than one PD per year had significantly more complications. Under direct supervision of an experienced surgeon PD can be performed safely as a teaching operation. A caseload of at least one resection per year seems necessary for consistently good results.

Since its first description by Codivilla [1], Kausch [1], and Whipple [2], pancreatoduodenectomy (PD) has remained one of the most complex abdominal operations. Perioperative complication rates of up to 59% [3] and perioperative mortality (30 dM; mortality within 30 days postoperatively) up to 25% [4, 5] together with the dismal long-term results regarding pancreatic carcinoma, the most frequent indication, less than 20 years ago led to publications advocating abandonment of PD [6, 7]. During the last few years, however, several authors have been reporting outstanding results after PD regarding complication rates as well as 30 dM [8–11]; even 5-year survivals after resection for cancer have seemed to improve [11–14].

Still, resection of the head of the pancreas, duodenum, common bile duct, in most cases the distal part of the stomach and eventually mesenteric vessels, extensive lymphadenectomy, and complex reconstructions with three to five intestinal anastomoses make PD one of the most difficult abdominal operations. PD demands a high degree of surgical expertise, and some regard a high personal or institutional caseload per year necessary to main-

tain a standard of consistently good results [3, 10]. To our knowledge, no publication so far has concentrated on the means and methods of training for surgeons to reach this level of expertise. The aim of this study was to evaluate whether transfer of expertise by teaching this complex operation would affect perioperative complication rates and the duration of surgical procedures. We also assessed the impact of the personal annual caseload.

Methods

Charts of 130 consecutive patients who had undergone pancreatic head resection between January 1994 and February 2000 at the surgical department of the University of Vienna's medical faculty were analyzed retrospectively. Two patients were excluded from the analysis because of the enormous extent of their resection as well as atypical underlying disease (extended gastrectomy for gastric cancer penetrating the pancreatic head in the first case and local recidivism after resection of a renal cell carcinoma in the second case).

Operations

Operations were performed in two settings.

- Group 1 (teaching operations; n = 49). A surgical resident with 5 to 7 years of training performed either the whole operation or at least the complete resection or the whole reconstruction phase assisted by an experienced surgeon (ES), usually an associate professor with more than 15 years of surgical practice (but not necessarily a specialist in pancreatic surgery). Typical operations performed by the residents on their own (without an ES in the operating room) were colonic and distal gastric resections (but not rectal resections or total gastrectomies).
- Group 2 (n = 79). An ES performed the entire operation with the assistance of less experienced colleagues.
- Resection was performed in two, reconstructions in three different techniques.
- "Standard" partial pancreatoduodenectomy (n = 33). This technique comprised resection of the distal part of the stomach, pancreatic head (usually transected in the portal vein's axis), common bile duct, duodenum (including the first approximately

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20 cm of jejunum), and (for malignant indications) regional lymphadenectomy (compartments I and II) as described by Trede and colleagues [11]. Reconstruction was carried out using a single Roux-en-Y loop for both pancreatic and bile duct anastomoses (followed by a Billroth II gastrojejunostomy including a side-to-side Braun-type jejunojejunostomy).

- Double-loop reconstruction (n = 68). After a resection similar to that described for the first technique, patients received separate Roux-en-Y loops for pancreatic and biliary anastomoses respectively, which has previously been shown to mitigate the consequences of a possible anastomotic insufficiency [15].
- Pylorus-preserving resection (n = 27). This was performed using the technique described by Grace et al. [16] and Braasch et al. [17].

The pancreatic anastomosis was usually performed using a one-layer end-to-end technique, except for seven operations where the pancreatic duct was drained without an anastomosis (which of course resulted in secretion for more than a week and was not regarded as a "fistula," as described later). Partial resection of the portal vein had to be performed in 19 operations because of tumor encasement; during teaching operations, even this advanced operative step has been performed by residents.

Endpoints

1. Mortality. Death within 30 days (or during the hospital stay) after operation regardless of whether procedure-related.
2. Complications. Graded as "severe" or "minor." Severe: potentially fatal intraoperative (bleeding) or postoperative complications (bleeding, anastomotic insufficiency with peritonitis necessitating reoperation). Minor: perioperative complications without immediate threat to the patient's life or long-term sequelae, as well as a postoperative pancreatic fistula, defined as percutaneous secretion containing pancreatic enzymes after postoperative day (POD) 7 with either drainage in situ or necessitating use of a stoma bag; pulmonary complications detected by significant implications on the patient's chart (fever, antibiotics, bacteriologic tests). Additional fistulas: Fistulas following reoperation for peritonitis were not included in the group of "plain fistulas," as these patients are included among those with "severe complications."
3. Operating time. Calculated from skin incision to insertion of the last skin staple.
4. Blood transfusions. Units of packed cells transfused during the operation.
5. Duration of stay. Time from operation to discharge from the hospital.
6. Radicality of resection. R0, radical resection; R1, resections with microscopic tumor remnants; R2, macroscopically visible tumor left.
7. Assessment of the influence of personal caseload on results. Thirteen senior surgeons (experienced surgeons, as defined) performed only 24 pancreatic resections during the study period (mean 1.9, median 1.0). Results of this group (fewer than six resections) were compared to those of six surgeons who had proctored and performed between 6 and 61 resections (mean 17.3, median 9.0).

Table 1. Patient characteristics.

Characteristic	Group 1 (n = 49)	Group 2 (n = 79)
Age (years)	62.5 (22–86)	62.1 (25–83)
Gender (male/female)	26/23	53/26
Preoperative co-morbidity (ASA)	2.02	1.97
Type of resection A/B/C[a]	10/28/11	23/40/16
Malignant/benign	38/11	62/17
Tumor stage (I/II/III/IV)	10/9/18/1	25/5/30/2
Blood transfusions, mean (median)	3.12 (2)	2.95 (2)
Resection (R0/R1/R2)	31/5/2	52/7/3
Portal vein resection (tangential/cross)	8 (5/3)	11 (8/3)
Operating time (minutes), mean/median	415/393	404/393
Time in hospital (days), mean/median	16.7/14	20.1/16

ASA: American Society of Anesthesiologists.

[a]A: standard resection, one loop; B: standard resection, two loops; C: pylorus-preserving (see Methods).

There was no significant difference for any of the parameters for the two groups.

Table 2. Underlying diseases.

Underlying disease	Group 1 (n = 49)	Group 2 (n = 79)
Malignant disease	38	62
Pancreatic cancer	23	34
Cancer of papilla	12	14
Cancer of bile duct	2	8
Cystadenocarcinoma	—	2
Cancer of duodenum	1	—
Endocrine tumor	—	3
Cancer of antrum	—	1
Benign disease	11	17
Pancreatitis	6	9
Adenoma	4	3
Cystadenoma	1	4
Trauma	—	1

Statistical Procedures

To estimate the influence of teaching procedures, groups 1 and 2 were compared using the chi-square test and, when applicable, Fisher's exact test for nominal variables. Continuous parameters were compared by the Mann-Whitney U-test. Calculations were performed using the software package Statview for Macintosh (SAS Institute Inc., SAS Campus Drive, Cary, NC, USA).

Results

Eleven residents performed between 1 and 13 PDs (mean 4.5, median 4.0) in group 1. Nineteen ESs assumed responsibility for (meaning they operated or proctored) 1 to 61 PDs (mean 6.7, median 3.0); only seven of them were involved in the 49 teaching operations.

Patient Characteristics

Groups 1 and 2 (Tables 1, 2) were comparable with respect to age, gender, underlying disease, preoperative co-morbidity expressed as the American Society of Anesthesiologists (ASA) classification system score. The scale of grades (1–4) represents the significance

Table 3. Complications.

Complication	Group 1 (n = 49)	Group 2 (n = 79)
Severe complications	5 (10.2%)	13 (16.5%)
Perioperative death	2 (4.1%)	1 (1.3%)
Reoperation (patients)	3 (6.1%)	11 (13.9%)
Intraoperative bleeding	—	1 (1.3%)
"Additional" fistulas[a]	2 (4.1%)	7 (8.9%)
Minor complications	9 (18.4%)	16 (20.3%)
"Plain" fistulas	5 (10.2%)	12 (15.2%)
Pneumothorax	2 (4.1%)	—
Peripheral pulmonary embolism	—	1 (1.3%)
Delayed gastric emptying	2 (4.1%)	1 (1.3%)
Wound infection	—	1 (1.3%)
Percutaneous drainage (abscess)	—	1 (1.3%)
Overall complications	14 (28.6%)	29 (36.7%)

[a] Fistulas following reoperations. Patients are therefore included under severe complications.

There were no significant differences for any of the complications for the two groups.

Table 4. Complications by surgeons with six or more resections (during 6 years) compared to those with five resections or less.

Parameter	No. of complications, by no. of resections		
	≥ 6 Resections (n = 104)	≤ 5 Resections (n = 24)	p
Severe complications	11 (12.9%)	7 (38.9)	0.0085
Reoperations (patients)	8 (7.7%)	6 (25)	0.0143
Perioperative deaths	2	1	NS
Minor complications	19 (20.4)	6 (35.3)	NS
Fistulas	17 (16.3)	9 (37.5)	0.020
All complications	30 (28.9)	13 (54.2)	0.0179

of a patient's illness prior to anesthesia), tumor stage, type, extent and radicality of the resection, and the duration of the hospital stay.

Mortality

The overall 30-day mortality was 2.3% (identical to in-hospital mortality). None of the deaths was related to the operative procedure. Two patients of group 1 died because of pulmonary embolism on POD day 3 and myocardial infarction during the operation, respectively. One patient from group 2 with a primarily uneventful course was found dead in the morning of POD 4; postmortem examination led to the hypothesis of a spontaneous cardiac arrest because of a vagal reflex following aspiration.

Complications

Severe Complications. Three patients of group 1 (6.1%) had to be reoperated (Table 3), compared to 11 (13.9%) reoperations in group 2. Nine of the reoperations were necessary because of postoperative bleeding; one patient had to undergo a third operation for intestinal obstruction with extended resection of the small bowel because of herniation through the mesocolon incision on POD 22. In a patient reoperated for hematoma, insufficiency of the pancreatic anastomosis was found as well. Five patients were reoperated for peritonitis following insufficiency of the pancreatic anastomosis: one of them twice and another one nine times. All of them recovered and were discharged in good condition. One patient of group 2 suffered massive hemorrhage during resection because of laceration of the portal vein, necessitating transfusion of 20 units of packed cells.

Minor Complications. There were two cases of pneumothorax (Table 3), not procedure-related (one following puncture of the subclavian vein after induction of anesthesia and the other developing spontaneously after extubation), in group 1 compared with one case of peripheral pulmonary embolism in group 2, a patient who had to undergo percutaneous drainage of a subphrenic abscess 12 days after PD and a subcutaneous wound infection. Three

patients showed delayed gastric emptying, necessitating a gastric tube for more than 1 week. None of these complications had any long-term sequelae.

Pancreatic Fistulas. Nineteen (24.1%) patients of group 2 were discharged with either a drain in situ or use of a stoma bag to collect pancreatic secretion; seven (14.3%) patients in the teaching group developed a fistula (NS). Nine patients who developed fistulas after reoperation for insufficiency of the pancreatic anastomosis were excluded when calculating the total number of complications (leaving 5 and 12 "plain fistulas").

Overall Complications. This group included those with "severe" and "minor" complications but not those with "additional fistulas," as the latter patients are included in the group with "severe complications." There were 14 (28.6%) complications in group 1, which is not significantly different from the 29 (36.7%) in group 2. Complications were distributed evenly between the single-loop and double-loop reconstruction techniques.

Operating Time

The mean operating time for the teaching operations (group 1) was 415 minutes (240–600 minutes) versus 404 minutes (265–645 minutes) for group 2. Patients with partial resection of the portal vein were distributed evenly: 8 in group 1 (16.3%) and 11 in group 2 (13.9%).

Blood Transfusions, Duration of Stay in Hospital, and Radicality of Resection

The amount of transfused blood, the time from operation to discharge from hospital, and the radicality of the resection (as expressed by R0, R1, or R2) did not differ between groups 1 and 2 (Table 1).

Influence of Personal Caseload on Results

Surgeons who performed fewer than six pancreatic resections during the study period (i.e., less than one resection per year) performed significantly worse than their colleagues. Reoperations (7.7% vs. 25%), severe complications (12.9% vs. 38.9%), and fistulas (16.3% vs. 37.5%) occurred significantly more often in patients operated on by less experienced surgeons (Table 4).

Discussion

When compared to results in publications of only 20 years ago [5, 7], the rates of short-term and long-term complications of PD have improved enormously during the last few years. Perioperative mortality (30 dM) rates of 0 to 5% [3, 8, 11, 12, 16–21] and an overall complication rate of less than 40% have been reported by several groups [3, 21, 23–26].

Although impressive, such results may not reflect the truth (i.e., the outcome of PD in large health regions [2–29]). Rather, they may represent excellent single-center figures. Neoptolemos and coworkers [10] analyzed 1026 PDs performed in 21 specialist units and compared the results to a multicenter study from a large health region [28], where operations had been performed by general surgeons. Specialist units had a mean caseload of 5.5 PDs per year, compared to 0.5 annual resections in general surgical departments (without mentioning the number of surgeons involved in the PDs); the 30 dM of specialists was 6% versus 28% for general surgeons. The authors concluded that specialist pancreatic units perform better than those performing PDs only sporadically and suggest a cutoff at 5 to 7 PDs per year and institution. Glasgow and Mulvihill [30] also showed that "low volume centers" with fewer than two pancreatic resections per year perform worse than specialist units. Edge and coworkers [31] compared complication and mortality rates of 91 surgeons from 26 institutions who had performed more than 200 pancreatic resections within 2 years. The median caseload per surgeon was 1 (51 had performed only one resection in 2 years), with a range of 1 to 15. The mortality rates were comparable (6%), but surgeons with more than four operations in 2 years had significantly fewer complications. Recently, Gouma and Obertop [32] concluded that conservative treatment as well as surgical palliation could be managed in community hospitals, but candidates for PD should be transferred to specialist centers.

The literature on surgical training, proctoring, and teaching operations is generally sparse [33–36], particularly concerning complex operations [37–43]. Parikh and colleagues [39] analyzed 38 gastrectomies done by a single surgeon and found that the learning curve lasted for 2 years or 25 operations. Watson and coworkers [40] suggested "experienced supervision during the learning curve" of laparoscopic fundoplication. Matthews et al. [41] found better results for surgeons performing more than three esophageal resections per year when compared to colleagues with a lower caseload, and Porter et al. [42] concluded similarly after working up almost 700 rectal resections. Phillips and coworkers [37] scrutinized the results of a study that included 4000 patients with large bowel cancer in Great Britain and found widely varying results. Local recurrence rates after anterior resection for rectal cancer differed from less than 5% to more than 20% for individual consultants, but there was no difference when the operation had been a teaching procedure or had been performed by the consultant. Recently, Singh and Aitken [43] reported on more than 245 colorectal resections and compared mortality, morbidity, and the 5-year survival. There was no difference if the operations had been performed by a consultant, supervised by him or her, or carried out by independent trainees.

In our study the mortality and severe complication rates of 2.3% and 14.1% (whole study group), respectively, are comparable to the results of similar cohorts of patients reported elsewhere [20, 22, 27, 44, 45]. Moreover, in no case was perioperative

mortality procedure-related. Although the complication rates for groups 1 and 2 did not show a statistically significant difference (28.6% vs. 36.7%), the overall complication rates seemed to indicate a trend toward better results in the teaching group. Several possible explanations must be examined: One could suspect a selection bias regarding the technical difficulty of cases, leaving the "easier" cases to residents. However, the rate of portal vein resections, representing a considerable extension of the procedure, was similar in the proctored patients.

Reflecting the findings of Phillips et al. [37], another possible explanation may be the expertise and caseload of the teaching surgeon, who is "transferring" his or her experience and complication rate to the resident. In fact, all of the teaching operations were proctored by only seven ESs. The significantly inferior results of surgeons who performed less than one resection per year seem to offer a key message: With a personal caseload of at least one pancreatic resection per year, an ES can safely pass on expertise during teaching operations. The ES's and the resident's results will be consistently superior to those of surgeons performing PD only occasionally.

Résumé. La duodénopancréatectomie céphalique (DPC) est devenue une intervention de pratique courante. Les séries récentes rapportent une mortalité péri-opératoire de 5% ou moins, une morbidité modérée, ainsi qu'une survie à long terme améliorée. Néanmoins, comme il s'agit d'une des opérations abdominales les plus complexes, une pratique régulière (nombre de cas réalisés personnellement) semble essentielle pour avoir de bons résultats. Les objectifs de cette étude rétrospective ont été d'évaluer si la DPC peut être réalisée avec sécurité lorsqu'on l'apprend à un autre chirurgien et si le nombre de cas réalisés par le chirurgien senior influence la morbidité et la mortalité. On a analysé les résultats de 128 DPC consécutives, réalisées dans un grand hôpital universitaire recevant des résidents. Quarante-neuf interventions ont été réalisées par 11 résidents (R) du département de chirurgie sous la supervision d'un chirurgien expérimenté (senior) (ES) (groupe 1) et les résultats ont ensuite été comparés aux résultats des interventions réalisées par le chirurgien ES seul (groupe 2, n = 79). Trois patients sont décédés de causes sans rapport avec l'intervention (2 dans groupe 1). Onze patients du groupe 2 ont nécessité une réintervention comparés à trois dans le groupe 1 (NS). Le nombre total des complications ainsi que le nombre de fistules étaient comparables dans les deux groupes. Les chirurgiens réalisant moins d'une DPC par an avaient significativement plus de complications. Sous la supervision directe d'un chirurgien expérimenté, la DPC peut être réalisée avec sécurité en tant qu'intervention d'apprentissage. Réaliser une intervention par an est un strict minimum pour obtenir de bons résultats.

Resumen. La pancreatoduodenectomía (PD) se ha convertido en un procedimiento rutinario. Las series informadas más recientemente señalan tasas de mortalidad perioperatoria de 5% o menos, morbilidad moderada y mejor supervivencia a largo plazo. Sin embargo, puesto que se trata de una de las más complejas operaciones abdominales, parece esencial poseer una determinada experiencia personal para lograr resultados aceptables. El propósito de este estudio retrospectivo fue determinar si la PD puede ser realizada como una operación de enseñanza y si la experiencia personal, en términos del número de casos operados 'por el cirujano senior afecta la morbilidad y la mortalidad. Se revisaron las historias de 128 pacientes sometidos a PD consecutivas en un hospital universitario; 49 operaciones fueron practicadas por once residentes (R) de cirugía como operaciones de enseñanza bajo la supervisión de un cirujano experto (CE), las que fueron comparadas con las operaciones realizadas por el mismo CE (grupo 2, n = 79). Tres pacientes murieron por causas no relacionadas con el procedimiento (2 en el grupo 1). Once del grupo 2 tuvieron que ser reoperados, contra 3 en el grupo 1 (NS). El número total de complicaciones, lo mismo que el grupo de fístulas pancreáticas, fue comparable en los dos grupos. Los cirujanos que practican menos de una PD anual registraron significativamente más

complicaciones. En conclusión, la PD puede ser practicada en forma segura como operación de enseñanza bajo la supervisión de un cirujano experto. Se requiere por lo menos la experiencia de una PD anual para lograr buenos resultados en forma consistente.

Acknowledgments

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