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ORIGINAL ARTICLE

Strengths, Weaknesses, Opportunities, and Threats of Centralized Pancreatic Surgery: a Single-Center Analysis of 3000 Consecutive Pancreatic Resections

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Abstract

Background Pancreatic surgery at high-volume centers has undergone major changes over the last decades. However, the quality of surgery remains to be considered as one important factor for achieving long-term survival especially in patients at advanced stages of disease.

Methods Between January 1990 and June 2017, 3000 consecutive patients have undergone pancreatic resections at our institution. Relevant postoperative data and histopathological findings as well as overall survival were analyzed. In addition, a SWOT (strengths, weaknesses, opportunities, threats) analysis of pancreatic surgery at high-volume centers was performed.

Results A total of 2218 pancreatic head resections (74%), 494 distal pancreatectomies (16%), 200 total pancreatectomies (7%), and 88 other resections (3%) were performed within our study period. Despite additional vascular resections in 265 patients (9%) and additional liver resections in 167 patients (6%), overall perioperative mortality did not exceed 3%. Overall survival strongly depended on the underlying disease, as well as on lymph node stage ($p = < 0.001$) and surgical radicality ($p = < 0.001$).

Conclusions The decentralization of pancreatic surgery over the last decades has led to a focus on high-volume centers to perform extended procedures in complex patients. The present SWOT analysis underlines the significance of a centralization of pancreatic surgery for patient safety and to increase the chance of long-term survival.

Keywords Centralization · High-volume center · Pancreatic surgery · SWOT analysis

Introduction

Indications for pancreatic resections nowadays range from benign entities to borderline resectable tumors of the periampullary region.[1] The progress in interdisciplinary perioperative and postoperative management and surgical expertise, as well as in patient selection and (neo-)adjuvant therapy options over the last decades, has led to distinct improvements in postoperative mortality rates and overall patient outcome.[2–4] Postoperative morbidity however remains high and is reported from 46 to 54%.[5,6] Especially postoperative pancreatic fistula formation (POPF) and postoperative pancreatic hemorrhage (PPH) are to be seen as the major and most challenging complications after pancreatic surgery and may lead to infectious complications, reinterventions or relaparotomy, increased length of hospital day, and even death.[7–10] Besides histopathological parameters such as resection margin, lymph node, perineural and lymphovascular status, tumor diameter of < 30 mm, and well or moderate tumor differentiation, the immediate surgical outcome has been identified as an important prognostic parameter for long-term survival after pancreatic surgery especially in underlying malignant disease.[11–15] The quality of surgery thus remains to be

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considered as one important factor to achieve long-term survival. Recent studies on nationwide outcome after pancreatic surgery have however demonstrated that postoperative morbidity and mortality rates are higher than anticipated and vary significantly between different institutions. Especially the influence of annual pancreatic surgery volume on surgical expertise and especially postoperative patient and complication management is debated controversially in this context.[16,17]

As in other fields of surgery, recent developments in surgical techniques such as the introduction of minimal-invasive and robotic-assisted techniques but also the promising results of multimodal, i.e., neoadjuvant treatment or enhanced recovery after surgery (ERAS), concepts have led to fulminant changes of standards and opportunities in pancreatic surgery over the last years.[18] It is thus essential to analyze where we stand and what we have accomplished in order be able to evaluate what we may achieve in the future.

A SWOT (strengths, weaknesses, opportunities, threats) analysis has been established as an interesting analyzing tool for this purpose, commonly used in business but also in nonprofit organizations and governmental units, to identify internal and external factors relevant in a field of interest. An analysis of this kind has however only rarely been performed in fields of clinical medicine but appears to be of great interest at this present time.[19] The aim of this study therefore was to analyze our own experience of 3000 consecutive pancreatic resections with regard to postoperative outcome and relevant parameters for long-term survival and to perform a SWOT analysis for evaluation of relevant dynamics and challenges of a pancreatic surgery program at high-volume centers.

Patients and Methods

Patient Selection and Study Design

In a retrospective analysis of a prospectively entered database, 3000 consecutive patients were identified who underwent pancreatic head resection, distal pancreatectomy, total pancreatectomy, or other pancreatic resections at our institution between January 1989 and June 2017. Indications for pancreatic surgery included pancreatic adenocarcinoma, papillary carcinoma, distal bile duct carcinoma, duodenal carcinoma, chronic pancreatitis, neuroendocrine tumor, and other indications such as cystic pancreatic lesions, adhesion/infiltration/metastasis of other gastrointestinal malignancies or renal cell carcinoma, lymphoma, or trauma Table 1.

Primary study endpoints were defined as the analysis of postoperative outcome and complications as well as overall survival. Secondary study points included risk factor analysis of relevant parameters with a possible prognostic relevance on overall survival.

Table 1 Patients characteristics

Number of patients	3000
Mean age (years) ± SD	62 ± 12.8
Indications	
Pancreatic adenocarcinoma	1273 (42.4%)
Papillary carcinoma	219 (7.3%)
Distal bile duct carcinoma	256 (8.5%)
Duodenal carcinoma	33 (1.1%)
Chronic pancreatitis	594 (19.8%)
Neuroendocrine tumor	127 (4.2%)
others	498 (16.6%)
Operation	
Pancreatic head resection	2218 (73.9%)
Distal pancreatectomy	494 (16.5%)
Total pancreatectomy	200 (6.7%)
Others	88 (2.9%)
Additional vascular resection	265 (8.8%)
Additional liver resection	167 (5.6%)

An additional SWOT analysis was performed based on our own quarter century experience as well as on recent trends and developments in pancreatic surgery at high-volume centers.

This study was performed in accordance with the Declaration of Helsinki and its amendments and approved by our institutional ethic committee. Written informed consent for surgery as well as for the use of clinical data was obtained from each patient in accordance with our institutional review board policy.

Preoperative and Intraoperative Evaluation, Surgical Technique

During the entire study period, all patients underwent routine preoperative evaluation including physical examination, routine laboratory examination including the tumor markers CA19-9 and CEA if indicated, and anesthesiologic operative risk assessment. The indication for pancreatic resection was based on the patient's clinical history and medical findings including preoperative imaging examination such as computed tomography (CT) and/or magnetic resonance imaging (MRI). The type of pancreatic resection was also decided on based on these preoperative but also on intraoperative findings. Especially extended pancreatic resections such as additional vascular or multivisceral resections including additional liver resections were performed based on an interdisciplinary individual case-by-case evaluation taking both local resectability and operative risk as well as preoperative patient education into consideration. The type of procedure with the pancreatic remnant after pancreatic head resection or distal

pancreatectomy was based on the intraoperative finding but mainly on the individual surgeon preference or in accordance with ongoing study protocols.[20,21] The type of reconstructions/closures included pancreatogastrostomy and pancreaojejunostomy after pancreatic head resection or hand-sewn and stapler closure after distal pancreatectomy. The standard technique for pancreatic head resection was pylorus-preserving pancreaticoduodenectomy (PPPD) if possible as opposed to classic Whipple procedure. All pancreatic resections were performed by experienced visceral surgeons and accompanied by standard lymphadenectomy or splenectomy if necessary. Recently, distal pancreatectomy was performed in minimal-invasive or robotic-assisted technique if possible. The decision on whether to perform neoadjuvant and/or adjuvant chemotherapy was based on the underlying diagnosis and current guidelines during each treatment time. For further analysis, we also divided our patients into two different time period groups depending on the time of pancreatic surgery (before 12/31/2004 group A, $n = 1349$ patients; after 12/31/2004 group B—1651 patients).

Data Collection

In accordance with our study endpoints, the following data were collected for each patient: demographics (gender, age); underlying diagnosis, margin resection status (R-status), T-stage, and lymph node status; details of the postoperative course such as postoperative morbidity and 30-day postoperative mortality and length of hospital stay: pancreatic fistula formation (POPF) and postpancreatectomy hemorrhage (PPH) were classified according to Clavien-Dindo and/or ISGPF/S definitions.[22–24] However, the ISGPS definitions for POPF and PPH were not published until 2004 and 2007 respectively. Complications of such kind before applicability of these standard definitions were thus retrospectively classified; overall survival was assessed by our surgical and oncological outpatient clinic.

Statistical Analysis

Statistical analysis was performed using PASW statistics 19 (SPSS Software, IBM Company, Chicago, IL, USA). For descriptive analysis, continuous variables were reported using mean or median values when appropriate with range, whereas categorical variables were described using frequencies and percent. Patient follow-up started on the day of surgery and survival was then measured until death or last-known follow-up. Overall survival was calculated by the Kaplan-Meier method and differences were compared by log-rank analysis. A p value < 0.05 was considered as statistically significant.

Results

Patient Demographics and Characteristics

Patient demographic data and indications for surgery are demonstrated in Table 1.

Peri- and Postoperative Course

A total of 2218 pancreatic head resections (73.9%), 494 distal pancreatectomies (16.5%), 200 total pancreatectomies (6.7%), and 88 other resections (2.9%) were performed within our study period. Additional vascular resections were performed in 265 patients (8.8%). One hundred sixty-seven patients (5.6%) underwent additional liver resection.

Postoperative complications ≥ Clavien grade II occurred in 784 patients (26.1%) with an overall postoperative mortality rate of 3.0% (91 patients). Clinically relevant POPF (grades B and C) occurred in 148 patients (6.7%) after pancreatic head resection, 91 patients (18.4%) after distal pancreatectomy, and 3 patients (1.5%) after total pancreatectomy. PPH occurred in 205 patients (9.2%) after pancreatic head resection, 39 patients after distal pancreatectomy (7.9%), and 11 patients (5.5%) after total pancreatectomy (PPH grade A—71 patients; grade B—61 patients; grade C—123 patients). Out of all 242 patients who had clinically relevant POPF, 78 patients (32.2%) also developed PPH. Insufficiency of hepaticojejunostomy occurred in 121 patients (5.5%) after pancreatic head resection and 17 patients (8.5%) after total pancreatectomy. Reoperations were performed in 370 patients (16.7%) after pancreatic head resection, 64 patients (13.0%) after distal pancreatectomy, and 39 patients (19.5%) after total pancreatectomy. Median length of hospital stay was 16 (± 20.4), 16 (± 21.0), and 19 (± 29.5) days after pancreatic head resection, distal pancreatectomy, and total pancreatectomy respectively. Overall 30-day postoperative mortality occurred in 62 patients (2.8%) after pancreatic head resection, 18 patients (3.6%) after distal pancreatectomy, and 9 patients (4.5%) after total pancreatectomy Table 2. Overall 60- and 90-day postoperative mortalities were 5.6 and 6.8% within our patient population.

The rates of postoperative complications > Clavien II, reoperations, and overall postoperative 30-day mortality were 18.8, 13.0, and 2.7% in time period 1 (before 2005) vs. 32.1, 18.3, and 3.3% in time period 2 (after 2004), respectively. There were no significant differences in the median length of postoperative hospital stay between the two time periods (16 vs. 17 days).

Final histopathological examination revealed tumor-positive lymph node status in 73.0, 50.7, 60.6, and 60.0% and a tumor-free resection margin (R0) in 66.1, 93.9, 78.0, and 88.9% of the patients with pancreatic adenocarcinoma, papillary carcinoma, distal bile duct carcinoma, and duodenal

Table 2 Operative and postoperative outcome

	Pancreatic head resections	Distal pancreatectomies	Total pancreatectomies
Surgical complications > Clavien II	543 (24.5%)	179 (36.2%)	51 (25.5%)
POPF (grade B/C)	148 (6.7%)	91 (18.4%)	3 (1.5%)
PPH (grade A/B/C)	205 (9.2%)	39 (7.9%)	11 (5.5%)
Insufficiency hepaticojejunostomy	121 (5.5%)		17 (8.5%)
Reoperations	370 (16.7%)	64 (13.0%)	39 (19.5%)
Median length of hospital stay (days)	16	16	19
30-day postoperative mortality	62 (2.8%)	18 (3.6%)	9 (4.5%)

carcinoma respectively. Overall radical surgical resection rate (R0) was 81.1% in time period 1 and 71.0% in time period 2.

Overall Survival and Risk Factor Analysis

Overall median survival was 32.5 (± 4.5) months in our entire patient population. Overall survival with regard to the underlying diagnosis is demonstrated in Fig. 1.

Seventy-two out of 265 patients (27.2%) who underwent additional vascular resections developed postoperative complications ≥ Clavien grade II, while postoperative mortality occurred in 13 patients (4.9%) in this group. Both parameters were not significantly increased in comparison to patients without vascular resection ($p = 0.688$, $p = 0.063$). Median length of hospital stay was however significantly longer in this group (18 vs. 16 days; $p = 0.04$).

In the group of 167 patients who underwent additional liver resection, postoperative complications ≥ Clavien grade II and postoperative mortality occurred in 67 patients (40.1%) and 10 patients (6.0%). Both parameters were significantly increased in comparison to patients without additional liver resection ($p = < 0.001$; $p = 0.022$). Median length of hospital stay was also significantly longer in this group (21 vs. 16 days; $p < 0.001$). Additional liver resection had however no statistically significant negative impact on overall survival in patients with periampullary carcinomas (pancreatic adenocarcinoma,

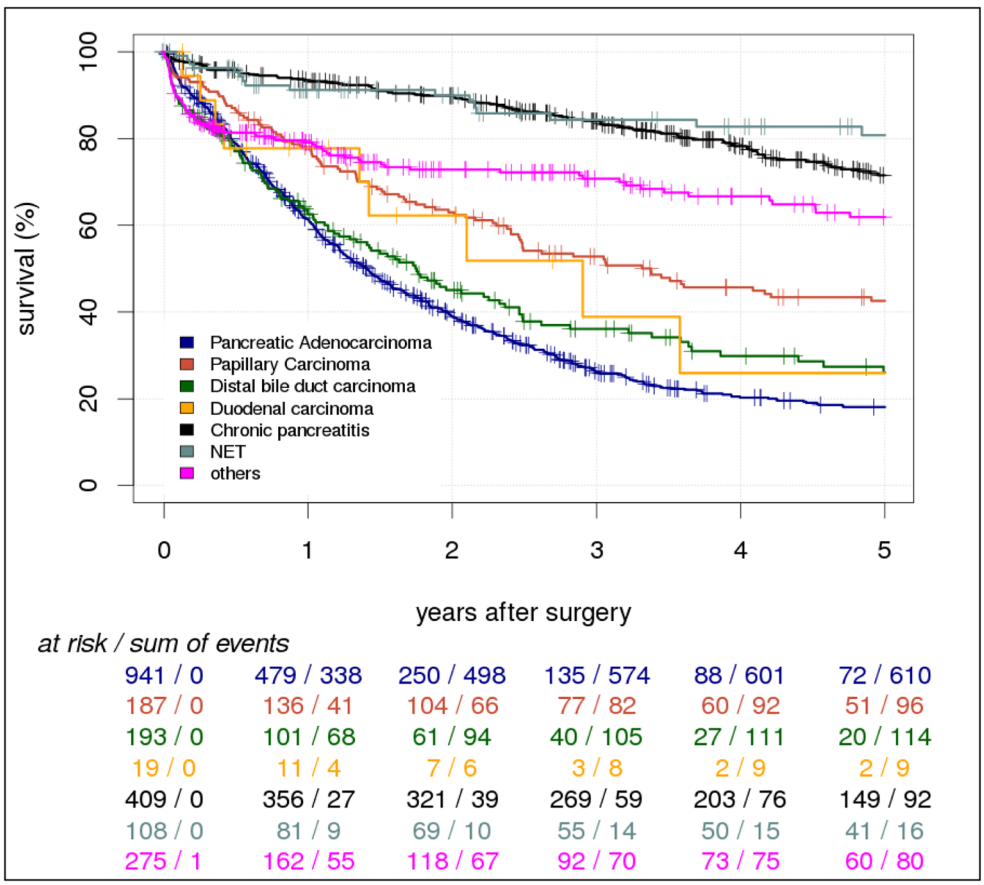

Fig. 1 Overall survival of patients who underwent pancreatic resection for pancreatic adenocarcinoma, papillary carcinoma, distal bile duct carcinoma, duodenal carcinoma, chronic pancreatitis, and neuroendocrine tumor

papillary carcinoma, distal bile duct carcinoma, duodenal carcinoma) as demonstrated in Fig. 2 ($p = 0.128$).

As additional prognostic relevant parameters, overall survival also strongly depended on the underlying disease, as well as on lymph node stage ($p = < 0.001$) and surgical radicality status ($p = < 0.001$) as demonstrated in Figs. 1, 3, and 4.

Discussion

A variety of studies have reported a general decrease in overall postoperative mortality after pancreatic resections over the last decades with postoperative mortality rates ranging from 2.3 to 7.8%.[2,25,26] In our analysis of 3000 consecutive pancreatic resections, we observed an overall postoperative mortality of 3% after all pancreatic resections. Overall postoperative morbidity > Clavien II was 26.1%. These rather promising results of our study most likely represent the general advantages of a high-volume hospital, which is underlined by recent analyses of nationwide databases by McPhee et al. or Nimptsch et al. who reported overall mortality rates ranging from 6.6 to 10.1% if the results of low-volume hospitals are included.[16,27]

Especially the risk of total pancreatectomy appears to be generally underestimated. While the apancreatic state reduces (not eliminates) the risk of POPF, postoperative mortality rates are still reported with up to 13%.[16] And, in contrast to pancreatic head resection or distal pancreatectomy, prospective randomized trials analyzing the outcome for total pancreatectomy until today remain scarce.

As another important finding of our study, we could also demonstrate that overall survival strongly depends on lymph node stage, on surgical radicality status, and most likely on the underlying disease. This is especially interesting since worldwide, we experience a significant increase in surgical indications for benign entities of the pancreas such as cystic lesions, chronic pancreatitis, and also neuroendocrine tumors. The favorable long-term survival for these entities in our study implicates that we may also have to start focusing on long-term results and treatment options after pancreatic surgery. The probability of symptomatic biliary strictures 5 and 10 years after pancreatic surgery for benign diseases was for example reported with 8 and 13%, respectively.[28]

Despite a shift in indications for surgery, the last years have also brought fulminant changes in treatment standards and opportunities including interdisciplinary multimodal treatment concepts for even advanced stages of

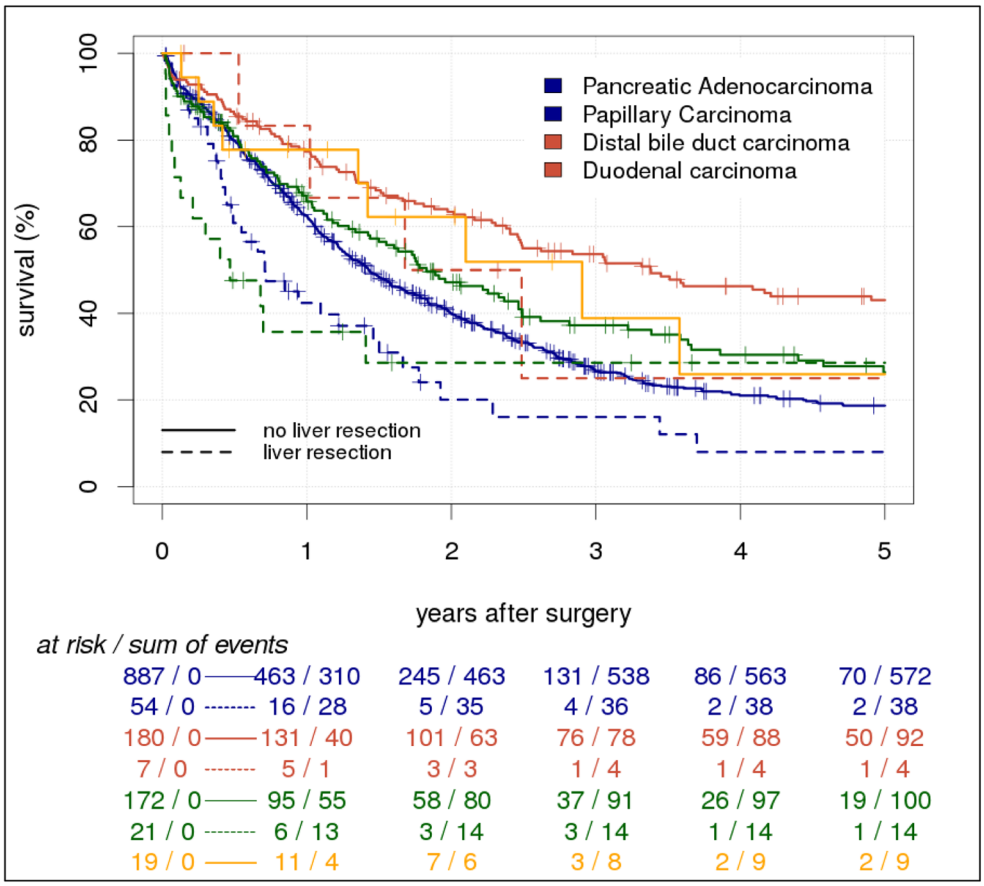

Fig. 2 Prognostic relevance of additional liver resection on overall survival of patients who underwent pancreatic resection for periampullary carcinomas (pancreatic adenocarcinoma, papillary carcinoma, distal bile duct carcinoma, duodenal carcinoma)

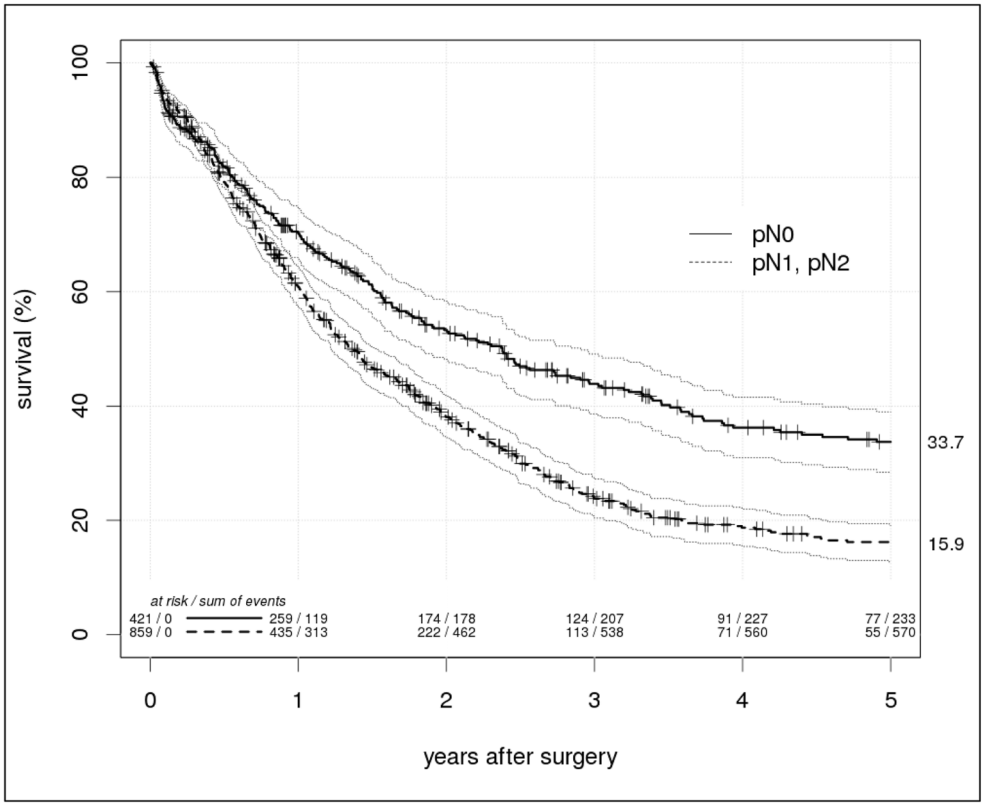

Fig. 3 Prognostic relevance of pN status on overall survival of patients who underwent pancreatic resection for periampullary carcinomas (pancreatic adenocarcinoma, papillary carcinoma, distal bile duct carcinoma, duodenal carcinoma)

malignant disease but also major changes in surgical techniques in general. At our institution for example, we have started to perform laparoscopic distal pancreatectomies in 2010 and established robotic-assisted distal pancreatectomy as a new standard in 2016.

With the opportunity of having analyzed 3000 consecutive pancreatic resections at our institution, as well as recent rapid changes in treatment standards and the ongoing debate on centralization of pancreatic surgery, we decided to perform the following SWOT analysis in order to possibly identify relevant internal and external factors in pancreatic surgery at high-volume centers (Fig. 5).

Strengths

Recent studies have shown clear evidence that the extent of annual volume of pancreatic resections is the most important prognostic parameter for postoperative outcome after pancreatic surgery with differences in postoperative mortality ranging from 5 to 10% in low- and high-volume hospitals.[17,27,29,30] This may of course not just be attributed to the surgical expertise alone but also to the proper management and thus outcome of patients with complications after pancreatic resections. Despite the surgeon's skill, the interdisciplinary setting for an early recognition and immediate appropriate management of surgical complications after pancreatic surgery is probably more important than in any other field of surgery. Delayed postpancreatectomy hemorrhage based on postoperative pancreatic fistula formation for example may be considered as the most relevant complication after pancreatic surgery and requires a 24-h availability of radiologic-interventional and/or endoscopic specialists for appropriate management. In our study, we observed an overall PPH rate of 8.5%, an overall rate of clinically relevant POPF of 8.1%, and rate of reoperations of 15.8%. Overall 30- and 90-day mortalities however did not exceed 2.8 and 6.8%. This low overall postoperative mortality may be the result of a balanced indication for early application of a non-surgical intervention and a protocol for early reoperation and underlines the strengths of a high-volume hospital.

Interestingly, in our study, the rate of postoperative morbidity > Clavien II was higher in time period 2 (after 2004) than in time period 2 (before 2005) (18.8 vs. 32.1%).

On the first sight, the combination of an increase in annually performed pancreatic resection accompanied by a higher rate of postoperative morbidity in time period 2 may appear contrary to the actual expectations for a high-volume center. In our belief, these results however most likely reflect the increasingly extended indications for pancreatic surgery over the last years with an increased overall risk for postoperative morbidity. As an important finding of our study, there were no significant differences in postoperative mortality rates between the two time periods though which may best be explained by the increasing opportunities and better outcome

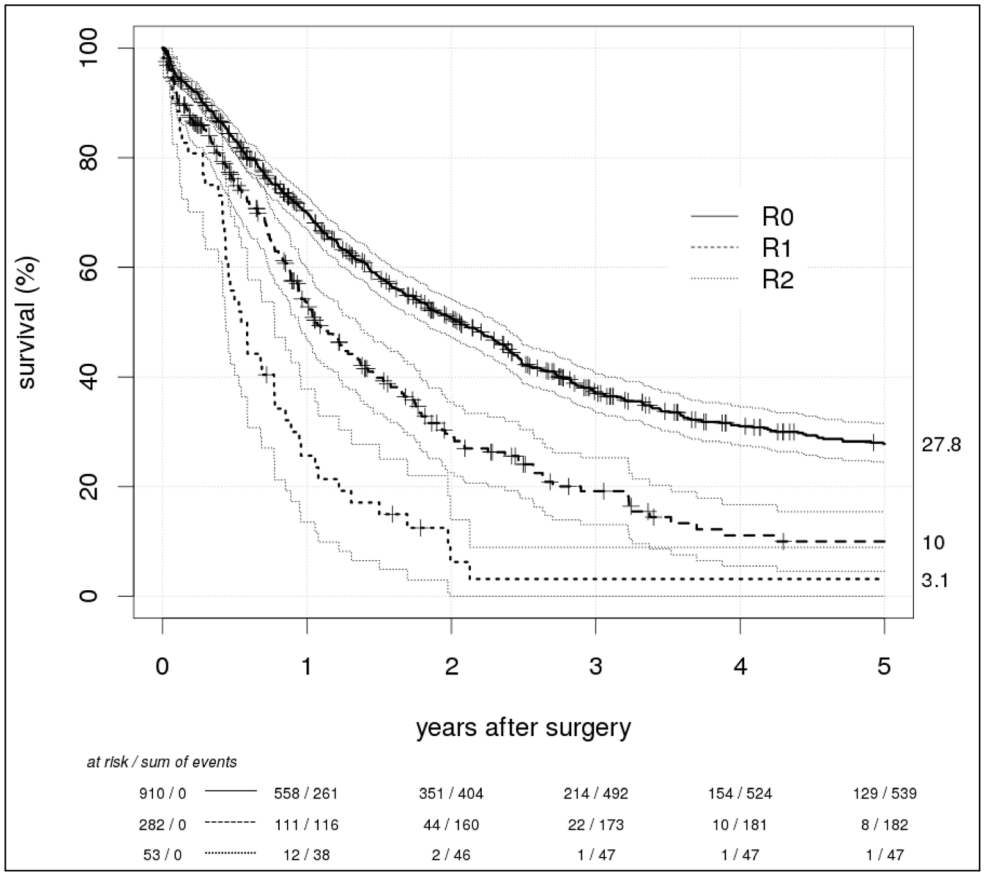

Fig. 4 Prognostic relevance of surgical radicality status on overall survival of patients who underwent pancreatic resection for periampullary carcinomas (pancreatic adenocarcinoma, papillary carcinoma, distal bile duct carcinoma, duodenal carcinoma)

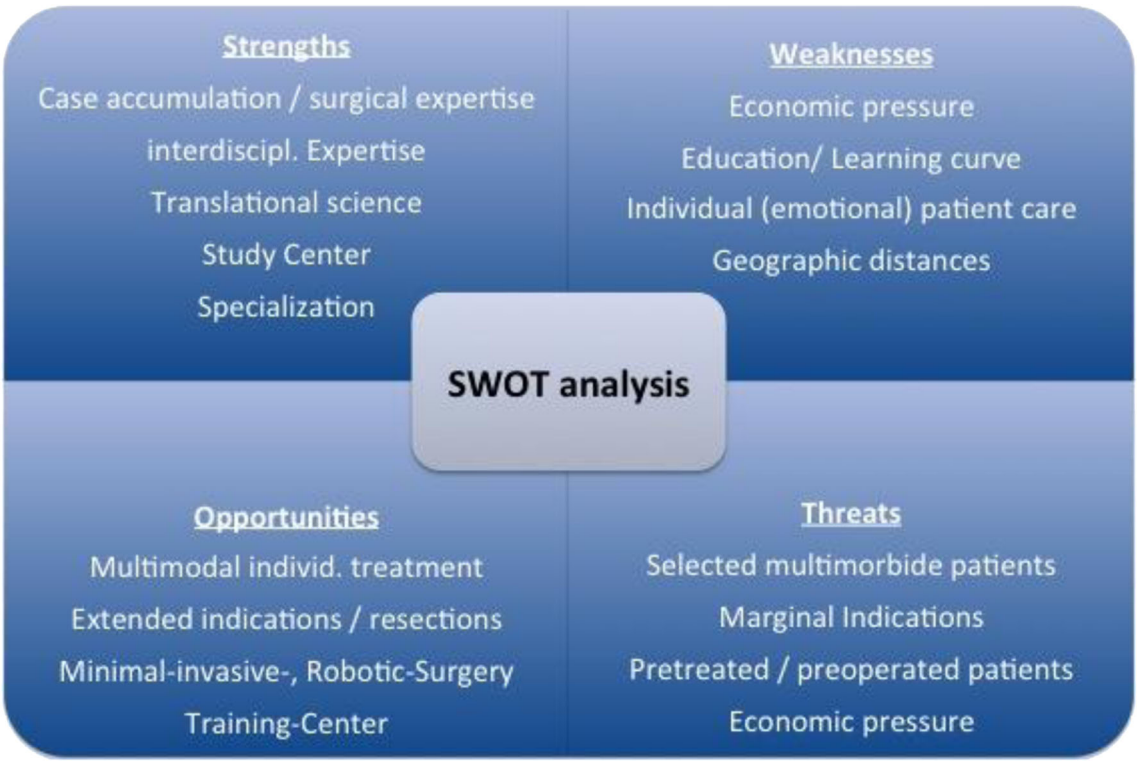

Fig. 5 SWOT (strengths, weaknesses, opportunities, threats) analysis of pancreatic surgery at a high-volume center

of postoperative complication management as an important strength of a high-volume center. Krautz et al. calculated a risk reduction for in-hospital mortality of 53% in high-volume hospitals compared to low-volume hospitals in this constellation.[17]

Efficient interdisciplinary treatment management however begins even before postoperative complication management and starts with a careful selection of patients undergoing pancreatic surgery. Recent developments in neoadjuvant treatment concepts for example have been shown to lower positive margin states, reduce nodal positivity, and improve overall postoperative survival.[31,32] At our institution, we have increasingly established neoadjuvant treatment concepts especially for borderline pancreatic adenocarcinoma over the last years and experience no differences in the rates of postoperative morbidity after prior neoadjuvant treatment.

Another clear opportunity of a high-volume center lays in the further implementation of enhanced recovery after surgery (ERAS) programs which have been shown to be effective in patients undergoing major pancreatic surgery but require the logistics of a broad multidisciplinary setting.[33]

The advantages of high-volume centers however go beyond classical clinical management. Recent changes in treatment standards as well as in surgical technical opportunities require specialized centers to perform on-time interdisciplinary/translational research for continuous evaluation of treatment options and techniques. A standardization of definitions and techniques is essential in this context for appropriate international evaluation. Both clinical implementation and academic analysis of novel treatment approaches may therefore best be achieved in the setting of a high case accumulation and high degree of interdisciplinary expertise.

Weaknesses

The increasing opportunities of treatment options and thus eventually costs per treatment are one of the most challenging tasks in several fields of clinical medicine nowadays. In pancreatic surgery, we especially cannot provide relevant data yet which assure cost-effectiveness of laparoscopic or even robotic-assisted pancreatic resections. A shorter length of hospital stay and also faster postoperative recovery will most likely justify these procedures also economically but in pancreatic surgery, we are generally faced with an additional high risk of postoperative complications as relevant contributor for additional financial resources per patient. The occurrence of POPF grade B for example was reported to cause a 33% rise—sixfold increase even in the event of POPF grade C—in hospital costs in comparison with uneventful patients.[9] The duration and extend of the postoperative inpatient treatment and not just the surgery alone thus determine the overall treatment costs of patients undergoing pancreatic surgery. Despite all progress in pancreatic surgery, the results of our study show an even increased risk for postoperative morbidity and mortality in time period 2 of our analysis (patients after 2004) with no significant differences in the length of postoperative stay between the two time period groups (16 vs. 17 days). While reinforcing a further centralization of pancreatic surgery, we are also forced to evaluate long-term cost-effectiveness of novel treatment opportunities.

Weaknesses of pancreatic surgery at high-volume centers may however not just be limited to financial matters alone. An important pursuit of a high-volume center is to provide education and teaching. With the increasing pressure of treatment and cost-effectiveness, this task however appears to be contrary to implement. In laparoscopic pancreatic surgery for example, especially the first 10 cases were reported to be the biggest hurdle with respect to operative time and intraoperative blood loss.[18] Boone et al. have also reported that it takes 40 robotic-assisted pancreatic resections for a relevant decrease of operative time and POPF rate.[34] It is therefore a difficult balance to provide cost-effectiveness and necessary education at the same time.

The increasing geographic "medical" distances as part of the centralization process lead to another important problem. Hospital readmissions after pancreatic surgery are reported in 12 to 59% often due to late postoperative complications and may even rise in the times of an increasing economic "early discharge" pressure.[35] Krautz et al. have demonstrated the importance of complication management in a high-volume setting.[17] Especially in the event of a postoperative emergency situation after discharge—out of the immediate geographic range of a high-volume hospital—geographic distances may be considered as an important limitation for postoperative outcome quality.

Opportunities

The interdisciplinary expertise in high-volume hospitals enables us to realize multimodal individual treatment concepts including extended resections for even advanced tumor stages. Additional venous resections for example—also in combination with prior neoadjuvant treatment—have been demonstrated to be safe and effective in the treatment of borderline resectable pancreatic adenocarcinoma.[14,36] Simultaneous arterial resections in contrast are generally seen as contraindicated due to the high rate of postoperative mortality and no benefits in overall survival.[36] Despite this recommendation, arterial resections and/or reconstructions may be necessary, i.e., in cases of an accidental injury of visceral arteries during pancreatic surgery or as part of the Appleby procedure for example. Several studies have also documented a benefit of additional liver resection for individually selected patients.[37,38]

In our study, a total of 167 patients underwent additional liver resection. Both postoperative complications ≥ Clavien

grade II (40.1%) and postoperative mortality (6.0%) were higher in this group of patients. Also, overall postoperative survival was decreased in comparison to patients without liver resection. Patients for simultaneous pancreatic and liver resection should therefore only carefully and individually be selected. In our belief, with the increasing opportunities of neoadjuvant and adjuvant treatment concepts, an increasing amount of patients may however be candidates for simultaneous or consecutive liver resection in the near future. These patients especially benefit from the setting of a high-volume center with the expertise for both pancreatic and liver resections.

Another opportunity of a high-volume hospital with large case load is the evaluation and implementation of minimal-invasive techniques such as laparoscopic and robotic-assisted pancreatic resections on a routine base. Advantages of both techniques have been reported with regard to intraoperative trauma and faster postoperative recovery with no disadvantages in overall oncological outcome.[39,40]

In contrast to other fields of surgery, the laparoscopic approach for pancreatic surgery may however be considered as more complex due to the retroperitoneal location of the pancreas with proximity to major visceral vessels and the necessity to perform complicated anastomoses especially during pancreatic head resection. A learning curve for laparoscopic as well as for robotic-assisted pancreatic resections of 30 to 50 cases has been reported to decrease operation times and postoperative complications.[34,41] Besides extensive technical requirements for both techniques, a large case accumulation appears to be a key determinant to improve the surgical technical skills and thus the overall clinical outcome. An increasing routine in both procedures also brings the opportunity to serve as a training center for a broader implementation of these rather complex procedures.

Threats

The continuously expanding patient selection criteria for pancreatic surgery may of course lead to an increased risk for postoperative morbidity and mortality accompanied by an increase of directly procedure-related health care costs. Elderly patients (age > 70 years) for example make up to 40% of patients undergoing pancreatic surgery nowadays with a disproportionally high risk of delayed postoperative recovery and/or postoperative morbidity and mortality.[16,42]

In our study, median patient age rose from 59.0 years in time period 1 to 64.0 years in time period 2, which may be part of the reason for the increase in overall postoperative morbidity in this same time period. Besides an adaption of postoperative recovery programs and health care cost calculations, we may also need to start focusing on establishing infrastructures to optimize postoperative outpatient care especially in these elderly and occasionally comorbid patients.

The progress in surgical expertise as well as in peri- and postoperative patient treatment has put us in a position in which we are able to perform extended resections for continuously expanding indications. Especially in patients with underlying malignant disease, it is however also essential to evaluate the individual oncological benefit especially with regard to long-term survival and quality of life parameters.

Another important task for future pancreatic surgery is to define reasonable limits in the process of a continuously increasing economic pressure. Despite all efforts to further reduce the duration of postoperative inpatient treatment, we have to take into consideration that 25% of the deaths after pancreatic surgery occur after postoperative day 30 and sometimes after discharge.[30] Another important aspect of centralization in pancreatic surgery worldwide is to consider hospitals at the border of the required annual pancreatic resection volume. A pure emphasis on procedure volume alone as the only quality indicator may create incentives for both hospitals and surgeons to perform marginal operations just to fulfill official volume criteria. This may indeed be seen as contrary to the initial goals of centralization.

Despite our findings, there are of course a few limitations to the present study. The study design is a retrospective single-center analysis over a long study period, which of course includes changes in treatment standards and definitions and thus a risk of a possible selection bias with regard to applied resection criteria and types of procedures performed.

Different indications and types of pancreatic resections may also to be seen differentiated with regard to peri- and postoperative risk parameters. A detailed comparison is therefore of course limit.

Conclusion

The results of our study outline the chances but also the challenges of modern pancreatic surgery at high-volume centers. In our belief, a reinforcement of a further centralization of pancreatic surgery appears to be the key determinant for further quality improvement of pancreatic surgery.

Credit for Authorship FK collected the data and wrote the manuscript. UP collected the data. RBS collected the data. TM collected the day. MF collected the data. TD collected the data. JP designed and performed the research. MB designed and performed the research.

All authors have made substantial contributions to the study, including conception and design of the study, the acquisition, analysis and interpretation of data, drafting or critical revision of the article, and final approval of the submitted manuscript.

Compliance with Ethical Standards

This study was performed in accordance with the Declaration of Helsinki and its amendments and approved by our institutional ethic committee. Written informed consent for surgery as well as for the use of clinical data was obtained from each patient in accordance with our institutional review board policy.

Competing Interests The authors declare that they have no conflicts of interest.

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