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Improving pancreas surgery over time: Performance factors related to transition of care and patient volume☆

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HIGHLIGHTS

- Pancreas surgery has evolved during last the last decades.
- Outcomes have been associated with hospital volumes.
- Acceptable and sustainable results can be achieved outside high-volume centers.
- To explain favorable outcomes, factors in addition to volumes are relevant.

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ABSTRACT

Background: Pancreas surgery has evolved with better diagnostic imaging, changing indications, and improved patient selection. Outside high-volume tertiary centers, the documented effect of evolution in care and volumes are limited. Thus, we aimed to review indications and outcomes in pancreas surgery during the transition from community-based hospital to a university hospital.

Methods: All pancreatic surgeries performed between 1986 and 2012 within a well-defined Norwegian population were identified from the hospital's database. Indications and postoperative outcomes, including mortality, were investigated.

Results: Of the 219 included patients (54% males; median age, 64 years), 150 (69%) underwent pancreatoduodenectomy; 55 (25%), distal resection; and 5 (2%), enucleation. The annual number of operations increased during the study period (from <10/yr to >20/yr). Most patients (169; 77%) underwent surgery for suspected malignancy. The 30-day mortality decreased significantly over time among patients treated for pancreatic cancer (from 16.1% to 3.5%; $p = 0.012$). Over time, significant reductions in median hospitalization time (19 versus 12 days; $p < 0.001$), re-operation rate (37.1% versus 8.4%; $p < 0.001$), and median ICU stay (3 versus 0 days; $p < 0.001$) were observed.

Conclusion: The transition to university hospital and increase in volume has led to significant improvements in several performance metrics and reduced postoperative mortality. We believe improved perioperative management and focused, multidisciplinary care-bundles to be of importance.

1. Introduction

Pancreatic surgery has undergone substantial changes over the last several decades and are now considered safe, albeit challenging, operations [1,2]. Recently, more attention has been paid to the postoperative outcomes of complex elective gastrointestinal surgery, and differences in outcomes between so called “low-volume” and “high-volume” hospitals have stimulated debate on the centralization of these operations [3–5]. Many assertions have been made in this debate; however, there are no firm conclusions regarding what constitutes “low-volume” versus “high-volume”, and the outcome criteria, patient referral bias, hospital case mix, and other confounding factors have not been defined [6–13]. Notably, favorable outcomes after pancreas surgery have been reported at lower volume centers [10,14–16]. Hence, numerous additional factors, such as a multidisciplinary approach that

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includes contrast-enhanced CT imaging, around-the-clock interventional radiology, multimodal oncology, advanced ICU care with anesthesiology, and full-time endoscopy services, have been recognized to be important for patient safety and to enable high-quality surgical management. Clearly, surgical knowledge and skills are crucial for obtaining good treatment outcomes; however, the availability of general competence and mutual capacity at a given hospital should be recognized in this context. A recent nationwide study from Sweden demonstrated that university hospitals had consistently good results compared with non-teaching hospitals, independent of the annual volume. The lowest "cut-off" per year was suggested to be 6 pancreatic procedures [17].

Here, we review the indications and outcomes of pancreatic surgery over a period of more than 25 years. We also discuss the development of a community-based hospital practice in a university hospital for a well-defined Norwegian population.

2. Materials and methods

2.1. Study population

Stavanger University Hospital (SUH) is currently the 4th largest hospital in Norway and belongs to the governmental heath care system. This system covers nearly all in-hospital medical care and is based on a universal health coverage system [18]. Therefore, all patients have equal access and rights to health care.

2.2. Patient identification and inclusion criteria

We searched the hospital's electronic patient administrative system for all patients who underwent pancreatic procedures between 1986 and 2012. Diagnosis-related ICD codes in combination with relevant surgical procedure codes (NCMP = Norwegian Classification of Medical Procedures) were used to identify patients. We included all patients who had any form of pancreas resection for any indication. Patients were excluded if they underwent exploratory procedures (i.e., laparotomy or laparoscopy) with or without a palliative bypass in the case of an inoperable tumor or any minimally invasive, endoscopic or per-cutaneous procedures on the pancreas or peri-pancreatic tissues if a surgical resection or correction procedure was not performed.

2.3. The evolving hospital

The population of the catchment area has grown from approximately 230,000 people in the mid-1980s to more than 350,000 at present, with SUH as the only hospital for this population. The hospital provides all surgical treatment for malignant and benign gastrointestinal diseases, with the exception of a few cases (e.g., organ transplantation) [18]. The hospital evolved from a Central Hospital, with an integrated clinical teaching program for medical students since 1997, to become officially a University Hospital in 2004, affiliated with the Medical Faculty at the University of Bergen (UoB). Thus, important changes in clinical content and care during this period have taken place, including improvements in radiology services [continuously improved CT technology, MRI availability, and around-the-clock interventional radiology services for the last decade] as well as increased access to subspecialty gastrointestinal radiological services. A specialized postoperative recovery service with round-the-clock monitoring is available for all major surgery patients, but also high-dependency ICU beds with ventilator support if necessary. The regular bed ward is staffed with personnel who are dedicated to upper gastrointestinal and HPB (hepato-pancreato-biliary) services. The clinical responsibility of HPB-surgery in particular, including performing or assisting at all operations, have been undertaken by one or two particular senior consultant surgeons at any time period, although a number of surgeons have contributed clinically.

Over the last decade, there has been an increasing emphasis on multidisciplinary evaluations and clinical decision-making to improve the surgical management of HPB patients, including pre-operative examinations, operative care and perioperative management. Services from a dedicated gastrointestinal nutritionist, and routine physical therapy postoperatively have been important parts of this approach. Patients are allowed and encouraged to consume food at will from POD 1 based on research from our institution [19]. A somatostatin analogue (Sandostatin™; 100 μg × 3 s.c.) has been routinely used for 7 days postoperatively since the late 1990s. Abdominal drains have been routinely used over the last fifteen years. Drains are removed as early as possible, usually on POD 2 or 3 after testing for amylase content. All patients receive thromboembolic prophylaxis with low molecular weight heparin (Enoxaparin, Klexane™ 40 mg s.c.) while under ward care.

Over the last decade, weekly formal multidisciplinary team meetings (MDT) between surgeons, oncologists, and radiologists who are clinically involved in caring for this particular group of patients provide greater contact and consultation between fellow physicians.

2.4. Time period definitions

For the analysis over time, we divided the study period into the following 3 time intervals: early (1986–1995), middle (1996–2005) and recent (2006–2012). The time periods are arbitrary regarding the evolution of care; however, they reflect periods of consistent change in the care process, and the most recent time period (7 years) incorporates the most updated multidisciplinary approach to the diagnosis, staging and management of patients with pancreatic disease.

2.5. Outcomes

We investigated changes in patient demographics, disease spectrum and procedure volume over time in relation to the process variables, such as perioperative variables (i.e., length of surgery, blood loss, re-operation rate and length of stay) and short-term mortality (30-day and 60-day mortality).

Demographic and clinical information, including operative notes and pathology reports, were retrieved from the hospital records.

Postoperative complications were classified according to Clavien-Dindo [20], in which grades III–IV are serious complications that require intervention (grade IIIa or IIIb) and/or may cause organ dysfunction (grade IVa or IVb), and grade V is defined as postoperative patient death.

2.6. Follow-up

An individual 11-digit ID number is assigned to all citizens of our country, and this enables complete follow-up until death or, emigration from the country (in case further follow-up is not possible). Follow-up information was collected from the hospital records as well as from outpatient clinic notes from several departments, including the oncology department, at the hospital. The date of death was confirmed using information from Statistics Norway. The civil data on patients in the electronic patient journal system at the hospital are updated from the National Population Registry. These data include the place of residence and living status (whether the person is alive or deceased).

2.7. Ethics

The Hospital Review Board approved the study as a quality assurance project (REC# ID 164/2011) according to the general guidelines provided by the Regional Ethics Committee.

2.8. Statistics

The statistical calculations were performed using IBM SPSS 22 for Mac (Chicago, IL). Assuming a non-normal distribution of variables, we applied non-parametric tests for the analyses. All the tests were 2-sided, and a P-value <0.050 was considered statistically significant.

3. Results

3.1. Hospital volume

As shown in Fig. 1, the annual number of pancreas resections was low during the first 10 years of the study period, but increased significantly with time. Almost half (43.4%) of the operations were performed during the most recent time period (2006–2012).

3.2. Patients

A total of 219 patients, including 118 (53.8%) males, with a median age of 64 (range, 17–87) years received surgical treatment of the pancreas for various conditions. The median age of the patients remained fairly stable during the study period. The patient characteristics are displayed in Table 1. The distribution between genders was nearly equal, and the majority of the patients (n = 194; 88.9%) had an ASA class of 2 or 3.

3.3. Indications

A pancreatic tumor, as determined by pre-operative imaging, was the indication for surgery in 169 (77.2%) of the operations. The remaining procedures were performed on 25 (11.4%) patients for different conditions. Most conditions were usually related to a previous event of acute or chronic pancreatitis. Notably, 20 (9.6%) of the resections, including 4 pancreatoduodenectomy (PD) operations, were performed for loco-regional pancreatic involvement by a malignant tumor in a neighboring organ (commonly gastric cancer). Very rarely (4; 1.8%), trauma prompted a pancreatic resection, and no Whipple procedures were performed for trauma.

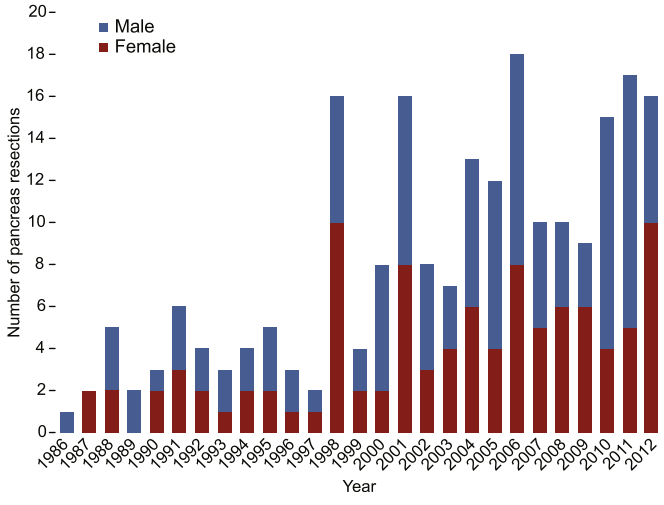

Fig. 1. Annual number of pancreas resections. Increasing number of pancreas resections performed in males and females during the study period of 27 years.

Table 1
Characteristics of the 219 patients.

Age, median (range), yrs	64 (17–87)
Gender	
Male	118 (53.9%)
Female	101 (46.1%)
ASA	
I	22 (10.0%)
II	107 (48.9%)
III	87 (39.7%)
IV	3 (1.4%)
Type of surgery	
PD[a]	150 (68.5%)
Dist. resection	55 (25.1%)
Tot. pancreatectomy	1 (0.5%)
Enucleation	5 (2.3%)
Other[b]	8 (3.7%)
Final diagnosis	
Ductal adenocarcinoma	66 (30.1%)
Ampulla Vaterii adenocarcinoma	26 (11.9%)
Distal cholangiocarcinoma	16 (7.3%)
NETs	15 (6.8%)
IPMN	14 (6.4%)
Duodenal adenocarcinoma	3 (1.4%)
Malignant overgrowth from other cancer (i.e., gastric or colon)	21 (9.6%)
Cystic neoplasm	14 (6.4%)
Autoimmune pancreatitis	26 (11.9%)
Trauma	4 (1.8%)
Benign, other	10 (6.6%)

[a] PD = pancreatoduodenectomy.
[b] Includes various procedures, such as a Beger procedure.

3.4. Operations

Pancreas head resection (PD) was most commonly performed (150; 68.5%), and pylorus-preserving pancreatoduodenectomy (PPPD) was performed in 120 (80%) of these patients; PPPD has been used more frequently in recent years. Distal pancreas resection was performed in 55 (25.1%) of the patients, with splenectomy accounting for 42/55 (76.4%) of these procedures. Enucleation of a benign tumor (e.g., insulinoma) was performed in 5 (2.3%) patients; this procedure was laparoscopically completed in 2 patients. Total pancreatectomy for IPMN (intraductal papillary mucinous neoplasm) was performed in 1 patient, and 8 (3.7%) patients underwent various surgical procedures after pancreatitis, including 1 Beger procedure for disabling chronic pancreatitis. The patterns of operations that were performed within the 3 time periods are depicted in Fig. 2. Of note, no vascular resections (i.e., resections of the portal or superior mesentery vein) were performed until the most recent time period (2006–2012), during which 10 (9.5%) such resections were performed, including 1 with graft replacement and 9 with primary anastomosis or a patch.

The median duration of the operations was 290 min (median for PD, 310 min; median for distal pancreas resection, 210 min), and there was a wide range in the duration (90–780 min). No significant change or reduction in the operative time was observed during the study period.

The estimated median perioperative blood loss for all the patients, including the trauma patients, was 950 ml (range, 20–9000 ml; interquartile range (IQR), 575–1500). More specifically, we compared the change in blood loss over time for patients who underwent a PD and observed a significant reduction in the median blood loss from 1250 ml in the first period to 800 ml in the most recent period ($p < 0.001$).

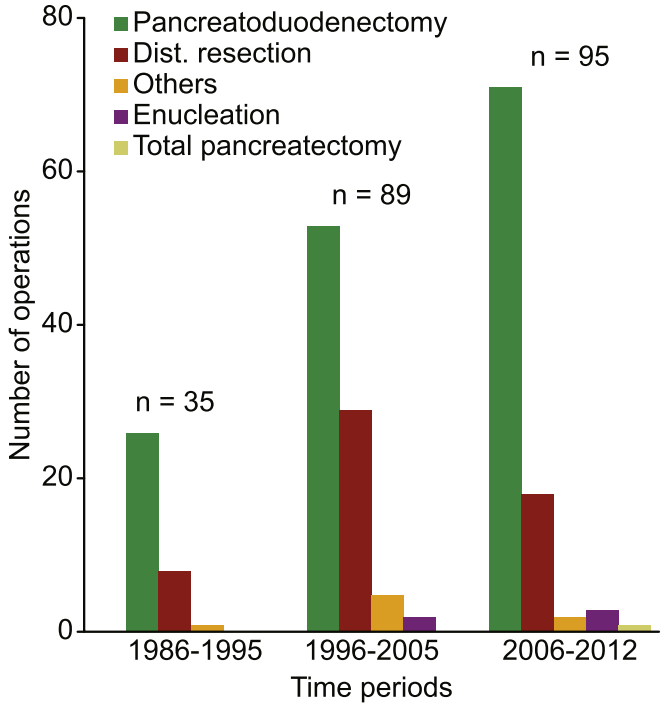

Fig. 2. Type of pancreas surgery by time periods. An increasing number of pancreaticoduodenectomies have been done during the study period. Of note, the last time period is 7 years.

3.5. Clinical outcomes

3.5.1. Length of stay (LOS)

During the study period, the postoperative LOS decreased from a median of 19 (range, 4–115) days in the first decade to a median of 12 (range, 1–124) days in the most recent time period ($p < 0.001$). A similar reduction was observed in patients who underwent a PD ($n = 130$) for a suspected pancreatic tumor, with a median LOS of 19(IQR 13–31) days in the first study period, and 12(IQR 10–22) days in the most recent study period ($p = 0.002$).

3.5.2. Use of intensive care resources

During the first decade, 32 (91.4%) of the 35 patients were admitted to the ICU. In contrast, 12 (12.6%) of the 95 patients who underwent an operation during the most recent 7-year time period were admitted to the ICU ($p < 0.001$). The length of stay in the ICU decreased significantly from a median of 3 (range, 0–35) days in the early decade to a median of 0 (range, 0–22) days in the most recent time period ($p < 0.001$). A similar significant reduction in ICU stay, from a median of 3 to 0 days, was observed for the patients ($n = 169$) who were surgically treated for suspected pancreatic tumors ($p < 0.001$).

Moreover, the same trend was observed in patients who underwent a PD ($n = 130$) for a suspected pancreatic tumor. Among patients admitted to the ICU, the length of stay decreased from a median of 4 (range, 1–35) days in the first decade to a median of 3 (range, 1–22) days in the second decade and to 2 (range, 1–22) days for the most recent time period ($p = 0.043$). Respiratory support followed the same trend and decreased significantly. These observations were independent of the inclusion of the total study population ($n = 219$) and of the restriction of the comparisons to patients who were surgically treated for a pancreas tumor ($n = 169$) or to those who underwent a PD ($n = 130$) for a pancreas head tumor identified by imaging. Specifically, for patients who were surgically treated for a recognized pancreas tumor ($n = 169$), the percentage of patients on postoperative ventilation decreased from 26.7% (8/30) in the first decade to 20.0% (10/50) in the second decade, with a further decrease to 5.9% (5/85) in the most recent time period ($p = 0.006$). For the patients in need of postoperative ventilation, the median respirator time decreased from 3 days in the first decade to 1 day in the most recent time period ($p = 0.192$).

3.5.3. Complications

Complications classified according to Clavien-Dindo as grade III or higher were encountered in 71 patients (32.4%). Infectious complications, including intra-abdominal abscess, postoperative hemorrhage, anastomotic leakage and postoperative pancreatic fistula, were most frequently encountered in patients with severe complications. As shown in Table 2, the pattern of complications were very much the same for the three time periods. While the proportion of severe complications gradually declined from 45.7% in the first time period to 29.5% in the recent time period, a statistical significance was not achieved ($p = 0.322$). However, the re-operation rate decreased significantly during the same time periods from 37.1% (13/35) to 19.1% (17/89) in the second decade, ultimately achieving a re-operation rate of 8.4% (8/95) in the last time period ($p < 0.001$). Of the patients who died during the postoperative course, re-operations were performed in 23 (82.1%) of the patients with grade IIIb complications, all of the patients with grade IVa ($n = 5$) and grade IVb ($n = 2$) complications, and 8 (53.3%) of the 15 patients with grade V complications.

3.5.4. Mortality

The overall 30-day postoperative mortality was 6.8% for all patients. As shown in Table 3, the overall 30-day mortality decreased during the study period without reaching statistical significance. In contrast, the overall 60-day mortality significantly decreased over time ($p = 0.031$).

Among the patients who were surgically treated for a suspected pancreatic tumor ($n = 169$) and those with a suspected tumor who underwent a PD ($n = 130$), both the 30-day and 60-day postoperative mortality decreased significantly over time (Table 2). From 1996 to present, our postoperative 30-day mortality after a PD has varied from 1.9 to 4.2%. The 60-day mortality has been between 5.6 and 7.4%.

4. Discussion

We found that improved perioperative care and increasing operative volume were significantly associated with better outcomes based on several performance metrics as well as with

Table 2
Postoperative complications according to time periods.

Complications	Time period		
	1986–1995	1996–2005	2006–2012
	(N = 35) (%)*	(N = 89) (%)*	(N = 95) (%)*
Anastomose leak	1 (2.9)	8 (9.0)	2 (2.1)
Pancreas fistula	1 (2.9)	3 (3.4)	4 (4.2)
Hemorrhage	5 (14.3)	9 (10.1)	4 (4.2)
Intrabd. abscess	2 (5.8)	4 (4.5)	10 (10.5)
Ileus/retension	1 (2.9)	2 (2.3)	4 (4.2)
Cardio-pulmonary	2 (5.8)	1 (1.1)	4 (4.2)
Infection	1 (2.9)	2 (2.3)	7 (7.4)
Sepsis, MOF	3 (8.6)	3 (3.4)	2 (2.1)

N = number of pancreas resections done during the time period.
* percent within the time period.
MOF = multi organ failure.

Table 3
Postoperative mortality according to time period and patient group.

	1986–1995 (n = 35)			1996–2005 (n = 89)			2006–2012 (n = 95)		
	All resections	Resections for suspected tumors	Pancreas head resections (PD)	All resections	Resections for suspected tumors	Pancreas head resections (PD)	All resections	Resections for suspected tumors	Pancreas head resections (PD)
	n = 35	n = 31	n = 26	n = 89	n = 51	n = 53	n = 95	n = 86	n = 71
30-d mortality (%)[a]	14.3	16.1	15.4	4.5	2.0	1.9	6.3	3.5	4.2
60-d mortality (%)[b]	23.1	22.6	20.0	3.8	3.9	5.6	5.6	4.7	7.4

[a] Comparisons of 30-d postoperative mortality by time period: all resections, p = 0.146; resections for suspected tumors, p = 0.012; pancreas head resections, p = 0.036.
[b] Comparisons of 60-d postoperative mortality by time period: all resections, p = 0.031; resections for suspected tumors, p = 0.003; pancreas head resections, p = 0.007.

reduced postoperative mortality. We believe this transition is due to both higher volume but also a more focused perioperative management and management care-bundles in a university hospital setting, which has evolved over time and across several disciplines. While the effect of each is hard to measure, we acknowledge that 'the sum is greater than its parts', and thus this is reflected in improved overall outcomes.

In agreement with previous reports [2,10,21–23], we observed that the number of pancreas resections increased and the perioperative mortality decreased during the study period. The postoperative 30-day mortality (15%) for pancreas resections in the early period was high but was in agreement with the figures reported by others from the same period [24,25]. More importantly, the consistently low postoperative mortality of 1.9–4.2% during the most recent decade corresponds with data from other updated series [22,25–27]. This applies to both patients with general pancreas resections as well as those who underwent a PD. Additionally, this holds true for 60-day postoperative mortality. Therefore, an improved 30-day mortality cannot be explained solely by the enhanced ability to keep patients alive longer (i.e., more than 30 days) due to improved ICU care. Moreover, the decrease in perioperative blood loss, shorter postoperative hospital stay, and minimal and continuously decreasing use of ICU resources indicate an appropriate standard of care for this group of patients in our hospital. A clinically important, yet not statistically significant, reduction in the incidence of severe postoperative complications (i.e., patients with complications of Clavien-Dindo grade III or higher) during the study period further illustrates this pattern of improvements. Furthermore, the statistically significant reduction in re-operation rate during the entire study period, with only 8.4% re-operations during the most recent time period (2006–2012), emphasizes the change in the management of complications that has occurred during recent years.

The current study assessed a series of pancreas resections that were prompted by several different indications to reflect the surgical approach for pancreatic disease in a well-defined Norwegian population. Therefore, the population per se (or surgical spectrum) may not be immediately comparable with institutions that have a tertiary referral profile or specialized function for specific surgical services. The reported epidemiology and incidence of peripancreatic malignancies is in the range of that for other Western countries; however, Norway has a lower incidence of acute and chronic pancreatitis compared with the UK or continental Europe [28,29]. Therefore, variations in the disease etiology between regions may also be reflected in the spectrum of procedures that are performed.

The observed improvements in several outcome measures (i.e., blood loss, ICU use, need for ventilation, and length of stay) can be somewhat explained by the improved knowledge and skills of all the professionals involved in the care of this particular group of patients. Additionally, changing policies (e.g., improved surgical techniques with an emphasis on meticulous dissection, routines for postoperative pain management, criteria for referral to ICU, and routine use of drains and nasogastric tubes) may have also contributed to the improved outcome pattern. In this retrospective study, we were unable to provide reliable details for every patient; however, our approach to perioperative care has been guided by making care easy according to the principles of enhanced recovery [30].

An inverse relationship between the postoperative mortality among patients surgically treated with complex procedures and hospital volume has been investigated and extensively evaluated in recent years [5,13,15,22]. This is also relevant for gastrointestinal surgery, including pancreas resections [2,4,14,24,25,31–34]. As a result, many countries have centralized the performance of certain complex procedures in an attempt to improve the surgical care and outcomes after such procedures [3,35–38]. Hospital volume is a simple measure that may be associated with improved patient outcomes; however, volume may not be the sole outcome determinant [17,31,34,39,40]. In addition to an increased number of operations at many institutions, several other changes have taken place in the management of pancreatic cancer patients over recent decades [30,41]. Imaging, pre-operative evaluation, and perioperative care have improved, as has our ability to select patients for complex surgery [23,41]. However, challenges remain as to show whether treatments goals have been achieved by the introduction of clinical measures and changes of care [42], and to define exactly which factors are of importance or which decisions are needed to arrive at an appropriate or optimal level of care [17,33,34,43–45].

The population-based design of our study is one of its many strengths.

The hospital is the only institution that offers surgical treatment for a geographically well-defined region. The government runs the health care system, and every citizen has access to the same level of care. A patient selection bias due to different referral policies (as can be encountered in many tertiary centers) is unlikely. The mix of cases in our study population likely reflects the general population. Additionally, long-distance patients, selection due to a lack of health care insurance, or various other non-medical reasons for biases are unlikely to have distorted the outcome interpretation [9,40]. However, some limitations should be addressed. The retrospective study design makes it difficult to provide reliable detailed data on some clinical aspects of interest (i.e., the true frequency and classification of postoperative pancreas fistula as well as delayed gastric emptying). Moreover, during an extended study period of nearly 3 decades, there have been numerous changes in imaging, surgical techniques, adjuncts (i.e., the perioperative use of somatostatin receptor analogues and antibiotic prophylaxis), and general routines in peri- and postoperative care [19] (including the recent implementation of the elements of an enhanced recovery policy [30]). Therefore, when improved outcomes are discussed, multiple factors should be entertained to explain these changes.

Surgical knowledge, individual skills and experience are all important. However, attention should be paid to several other

aspects, including perioperative care, the availability of the ICU, and 24/7 access to imaging and interventional radiology, when specialized units for pancreas surgery are defined [10,12,25,32,46].

Ethical approval

The Hospital Review Board approved the study as a quality assurance project (REC# ID 164/2011) according to the general guidelines provided by the Regional Ethics Committee.

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Author contribution

Please specify the contribution of each author to the paper, e.g. study design, data collections, data analysis, writing. Others, who have contributed in other ways should be listed as contributors.

JAS: study design, data, collection data analysis, writing the draft, and completing the final manuscript.

OMS: data collection, writing process, and completing the final manuscript.

KS: data collection, and analysis, writing process, and completing the final manuscript.

All authors have approved to the final version of the manuscript and to the submission of the paper.

Conflicts of interest

No conflicts of interest.

Guarantor

The Guarantor is the one or more people who accept full responsibility for the work and/or the conduct of the study, had access to the data, and controlled the decision to publish.

Research registration unique identifying number (UIN)

We have an unique (UIN) in the hospital's Research Review Board Committee ((REC # ID 164/2011).

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