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Pancreatic resections are not only safest but also most cost-effective when performed in a high-volume centre: A Finnish register study

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ABSTRACT

Background: It is not known whether the treatment costs of pancreatic surgery can be reduced by centralisation. The aim of this study was to analyse the impact of hospital volume on the short-term prognosis and costs in a nationwide study.
Methods: The National registry was searched for patients undergoing pancreatoduodenectomy (PD) in Finland between 2012 and 2014. Patient data was recorded up to ninety days postoperatively and Charlson comorbidity index (CCI) calculated. Complications were classified according to Clavien-Dindo. A CCI was calculated for each patient. The hospitals were categorized by yearly resection rate: high (≥20, HVC), medium (6–19, MVC) and low (≤5, LVC). Costs were calculated according to the 2012 billing list.
Results: The study population comprised 466 patients. Demographics were similar in the HVC, MVC and LVC groups. Mortality was lower in the HVCs than in MVCs and LVCs at 30 days (0.8% vs. 8.8–12.9%; $p < 0.01$) and at 90 days (1.9% vs. 10.5–16.1%; $p < 0.01$). Hospital volume and CCI were significant factors for mortality in multivariate analysis. Median costs among all patients were lower in the HVC group than in the MVC/LVC groups ($p = 0.019$), among Clavien-Dindo class III (0.020), among patients over 75 years ($p < 0.001$) and among patients who survived over five days ($p = 0.015$).
Conclusions: Thirty- and 90-day mortality is 10 times lower when the patient is operated on in an HVC. The study shows that the median overall costs of surgical treatment are 82–88% of the median costs in lower volume centres.

Introduction

Pancreatic surgery is known for its high postoperative morbidity and mortality. A centre performing pancreatic surgery needs to have expertise available every weekday around the clock to ensure a safe postoperative period. Centralisation of pancreatic surgery to high-volume centres has been reported to improve the short- and long-term prognosis. Postoperative mortality in particular has been reported to be lower in high-volume centres [1–5]. It has been suggested that larger centres have a better capability to recognize postoperative problems before they accumulate and result in the patient's death [6]. However, the effect of centralisation on the costs of treatment has been unclear. Various reports have been published, but variation in the methods and health care structures makes comparison between the reports challenging [7]. In Finland the centralisation of pancreatic surgery has proceeded gradually since the 90s. Pancreatic surgery is performed only in public hospitals. It is not known whether the costs of treatment can also be reduced by centralisation.

The aim of this study was to analyse the effect of hospital operation volume on the number of complications, postoperative mortality and costs of pancreatic resections up to 90 days postoperatively.

Patients and methods

The study was approved by the Regional Ethics Committee of Pirkanmaa (code R12241). The STROBE guideline for observational studies was followed. All patients undergoing pancreatic surgery (JLC*; Nordic Classification of Surgical Procedures) between 2012 and 2014 nationwide in Finland were selected from the Finnish

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Operation and Treatment Register (HILMO) in November 2016 and re-checked in March 2017. PDs (code JLC20, JLC30) were included in the study. Patients aged under 18 years and trauma patients were excluded. The HILMO register records all treatment episodes nationwide in Finland (involving any Finnish hospital). For this study, all treatment episodes of the patients included were selected up to 90 days postoperatively from the HILMO register. Patient files were collected from the associated hospitals according to the treatment episode dates retrieved from the HILMO register. Patient files were examined manually. From the patient files, data on medical history, resected tumour (diagnosis, TNM, gradus, R-status, size, number of total and positive lymph nodes), complications, procedures performed and the length of hospital stay and stay in intensive care were recorded. A Charlson comorbidity index (CCI) [8] was calculated for each patient. Patient data was examined for up to 90 days postoperatively at the operating hospital and also at possible other hospitals. The cut-point of survival was 1 February 2017.

Complications were classified according to the Clavien-Dindo classification [9] (C-D) according to the patient records. Delayed gastric emptying (DGE), pancreatic fistulas (POPF) and post-pancreatectomy haemorrhage (PPH) were classified according to the most recent international guidelines, clinically significant being grades B and C [10–12]. The grading was based on the data in the patient records. Data on other possible complications was also retrieved from the patient records. Unspecified infection was defined as a situation where antibiotics were initiated for a CRP reaction without specific target detected (findings in X-ray, CT, cultures, for example). Failure to rescue was defined as a patient having organ dysfunction requiring intensive care unit facilities, but still died during the ward episode.

To analyse the effect of hospital volume on patient data, operating centres were categorised as high (HVC; ≥ 20), medium (MVC; 6–19) and low (LVC; <6) volume pancreatic centres according to the mean yearly number of PDs and TPs performed for any diagnosis during the period 2012–2014.

The short-term prognosis was analysed as 30- and 90-day mortality rates. Multivariate analysis between different hospital volumes was performed with logistic regression analysis.

Cost evaluation was performed according to the 2012 pricelist of Tampere University Hospital and one local health care centre (Pirkkala in southern Finland) to be able to compare the actual cost differences, unaffected by possible billing differences between hospitals. The cost evaluation was the sum of costs of ward days, intensive care days, endoscopies performed, interventional radiology and re-operations as well as ward days in primary health care facilities totalling up to 90 days postoperatively. Because the pricelist was not comprehensive for all procedures, the mean price of the procedures was used. For intensive care and stays on the ward, the mean price of a normal care day and of an extra demanding care day was used because it was not possible to distinguish between these retrospectively. The primary operation costs were not included in the calculations, as this was considered similar across centres.

In the cost analysis, the costs of different levels of treatment were related to the cost of one postoperative day on a surgical ward (DHos = day at a hospital = 784 USD) and converted to factors accordingly: factor 1 DHos for a day at any hospital, 5.5 DHos (4,312 USD) for an intensive care day, 1.1 DHos (862 USD) for endoscopies or interventional radiology, 4.0 (3,136 USD) DHos for re-operations and radiologic angiographic procedures and 0.3 DHos (235 USD) for a day in primary health care.

Cost-benefit was analysed among patients with a primary pancreatic malignancy in relation to the surgical costs during the 90-day postoperative period in relation to survival gained during the first two years after surgery.

Continuous data is shown as median (range). Fisher's exact test, Chi-Square test and Kruskal-Wallis test were used to calculate statistical significance. Cost-effectiveness was analysed with logistic regression analysis. A p-value of ≤ 0.05 was considered statistically significant.

Results

Operations. The search identified 488 patients who had possibly undergone PD in Finland between 2012 and 2014. After studying patient records, twenty-two patients were excluded. The final study population consisted of 466 PDs.

Operating centres. There were two high (≥ 20 PD/year), 5 medium (6–19 PD/year) and 6 low (≤ 5 PD/year) volume centres. The median numbers of PDs per year were 47.3 (range 29–59), 13.7 (range 6–15) and 1.8 (range 0.3–3.3) in HVC, MVC and LVC respectively). Of the patients 263 (56.4%) were operated on in HVC, 172 (36.9%) in MVC and 31 (6.7%) in LVC respectively.

Demographic and surgical data. The demographics of the patients were similar in the HVC, MVC and LVC groups. The majority of patients had a malignant disease and the proportions (82, 86, 84%) were similar in HVCs, MVCs and LVCs ($p = 0.487$, Pearson Chi-Squared test). More vascular resections were performed in HVCs (16% vs. 4.1% and 3.2% in MVC and LVC; $p < 0.001$; Pearson Chi-Squared test). Table 1.

Complications. Overall complications classified according to C-D

Table 1
Demographics of the patients.

	HVC	MVC	LVC	p
Total,No	263	172	31	
Median age, years (range)	67 (26–86)	67 (30–85)	67 (47–85)	0.475[b]
Number of patients over 75 year, (%)	50 (19)	39 (23)	4 (13)	0.385[a]
M/F (%)	56/44	54/46	48/52	0.713[a]
ASA				0.306[a]
ASA 1	92 (35)	48 (28)	11 (36)	
ASA 2	78 (30)	65 (38)	12 (39)	
ASA 3–4	93 (35)	58 (34)	8 (26)	
ASA (patients over 75 years)				0.695[a]
Charlson comorbidity score, median (range)	5 (2–8)	5 (2–11)	4 (2–7)	0.676[b]
Number of vascular resections, (%)	46 (16)	7 (3.8)	1 (3.0)	<0.001[a]
Number of patients operated after neoadjuvant therapy, (%)	19 (7.2)	0	0	<0.001[a]
Number of resections with a malign diagnosis, (%)	214 (82)	148 (86)	26 (84)	0.487[a]

HVC = high volume centre, MVC = medium volume centre, LVC = low volume centre.
[a] Pearson's Chi squared test.
[b] Kruskall-Wallis.

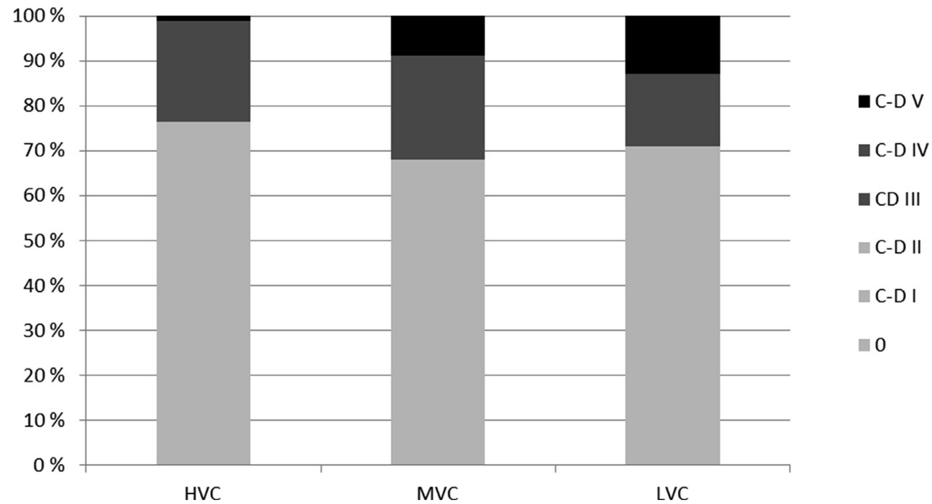

Fig. 1. Distribution of Clavien-Dindo (C–D) classes in different volume groups. (HVC = high volume centre, MVC = medium volume centre, LVC = low volume centre).

did not differ between volume groups except in mortality (C-D V: 1.1% in HVCs, 8.7% in MVCs and 12% in LVCs; p < 0.01, Pearson Chi-squared test). Fig. 1. The absolute number of PD-related complications was higher in lower volume centres than in high volume centres, but this did not reach statistical significance; DGE gr B–C (6.6–6.5-15%), POPF gr B–C (5.6-9.2-9.1%) and PPH gr B–C (5.3-6.0-9.1%) in HVC, MVC and LVC respectively. More unspecified infections were present in the MVC group (20% vs. 12% in HVC and 6.1% in LVC, p = 0.034, Pearson's Chi-squared test). More leakages in gastro-enterostomies/enteroenterostomies were present in the MVC group, but the total number was low (5, 2.7%, p = 0.013, Pearson Chi-squared test). Table 2.

Postoperative short-term survival. Both 30-day and 90-day mortality were significantly lower in the HVC group: the 30-day mortality rates were 0.8% in the HVC-group vs. 8.8% in the MVC-group and 13% in the LVC-group (p < 0.001, Pearson Chi-squared test) and the 90-day mortality rates were 1.9% in the HVC group vs. 11% in the MVC group and 16% in the LVC group (p < 0.001; Pearson Chi-squared test). In a logistic regression analysis considering sex, CCI and operation volume, CCI and operation volume were statistically significant variates in 30- and 90-day mortality rates. In a logistic regression analysis performed inside each volume subgroup (HVC, MVC, LVC), a single operating hospital was not a significant factor for 30-day and 90-day mortality (considering sex, CCI and hospital). No deaths occurred during the first 20 days postoperatively in HVCs. Among critically ill patients (C-D 4 and 5) signs of failure to rescue were apparent as more patients were lost in the lower volume groups than in the HVC group (p < 0.001 for MVC vs. HVC and p = 0.003 for LVC vs. HVC, Fisher's exact test). Table 3 and Fig. 2.

When patients over 75 years old were analysed, there were more critical complications (C-D 4–5) in the MVC group than in the HVC group (10% in HVCs and 33% in MVCs; p = 0.008, Fisher's exact test) and more patients were lost (0% in HVCs vs. 21% in MVCs; p = 0.002, Fisher's exact test). The LVC group comprised only four patients over 75 years old, which impeded the subgroup analysis among critically ill patients for the LVC group.

Use of health care resources for 90 days postoperatively. The median numbers of days spent in hospitals or in primary health care centres were 14, 16 and 16 days in the HVC, MVC and LVC groups respectively (range 2–90 days) without differences between the operating hospital volumes. Comparing different C-D groups there was a trend towards lower number of days spent in hospital in the HVC group. The difference was significant in C-D class 3 (p = 0.024, Kruskal-Wallis). The number of reoperations, endoscopies or

Table 2
Distribution of complications.

Complication, no (%)	HVC (n = 284)	MVC (n = 184)	LVC (n = 33)	p[a]
Leakages				–
Pancreato-jejunostomy, gradus B–C	16 (5.6)	17 (9.2)	3 (9.1)	0.306
Hepatico-jejunostomy, Clavien-Dindo III-V	11 (3.9)	8 (4.3)	1	0.927
Gastro/enteroenterostomy, Clavien-Dindo III-V	0	5 (2.7)	0	0.013
Haemorrhage	15 (5.7)	11 (6.4)	3 (9.7)	0.628
Delayed gastric emptying, gradus B–C	19 (8.8)	12 (7.0)	5 (16.1)	0.243
Infectious complications				
Infection NAS[b]	35 (13)	35 (20)	2 (6.5)	0.050
Pneumonia	26 (9.9)	19 (11)	3 (9.7)	0.921
Collection or abscess	24 (9.1)	9 (5.2)	0	0.085
Bacteraemia or candidaemia	8 (3.0)	9 (5.2)	0	0.262
Thromboembolic complications	10 (3.8)	9 (5.2)	1 (3.2)	0.7237
Wound problems				
Rupture of fascia	0	4 (2.3)	0	–
Wound infection	10 (3.8)	11 (6.4)	1 (3.2)	0.423
Resuscitation	0	2 (1.2)	0	–

NAS: use of antibiotics, but aetiology not unrevealed HVC = high volume centre, MVC = medium volume centre, LVC = low volume centre.
[a] Pearson's Chi squared.
[b] Infection.

Table 3
Logistic regression analysis of short-term mortality.

Variate		30-day mortality, p	OR (95% COI)	90-day mortality, p	OR (95% COI)
Sex	male	reference		reference	
	female	0.319	1.598 (0.0.636–1.945)	0.997	1.002 (0.452–2.222)
CCI		0.009	1.463 (1.100–1.945)	0.008	1.418 (1.097–1.832)
Operation volume		0.002		0.001	
	HVC	reference		reference	
	MVC	0.001	11.659 (2.611–52.053)	0.001	5.765 (2.083–15.959)
	LVC	0.001	20.286 (3.499–117,626)	<0.001	10.639 (2.873–40.146)

HVC = high volume centre, MVC = medium volume centre, LVH = low volume centre, OR = odds ratio, COI = confidence interval. CCI=Charlson comorbidity index.

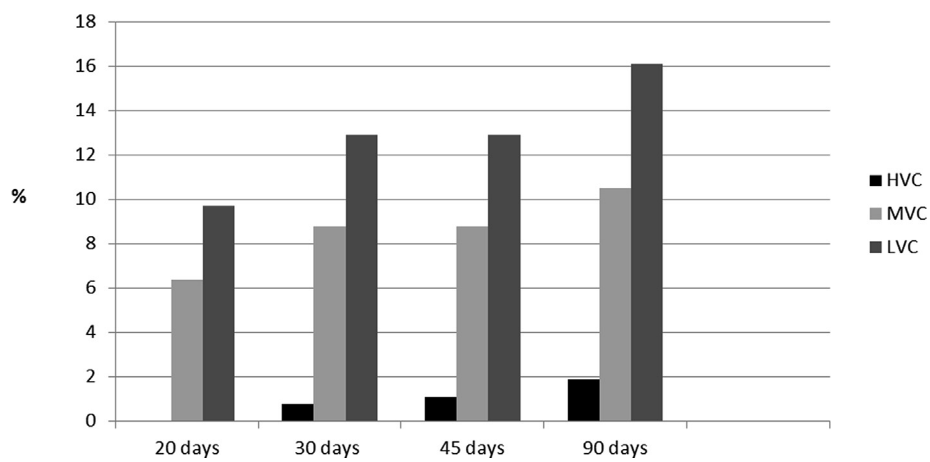

Fig. 2. Postoperative mortality in relation to operation volume. Mortality rates were lowest in the HVC group and patients were lost later ($p < 0.01$ for 30-day mortality and $p < 0.01$ for 90-day mortality; Pearson Chi-squared- test). . (HVC = high volume centre, MVC = medium volume centre, LVC = low volume centre).

radiological drainage procedures was the same in the different volume groups. Radiological procedures for vascular complications were only performed in high volume centres. Table 4.

Cost-analysis. Median costs were lowest in the HVC group (14 (10,976 USD) DHos vs. 17 (13,328 USD) DHos in MVC and 16 (12,544 USD) DHos in LVC; p = 0.019, Kruskal-Wallis) both analysing the data as a whole and considering only patients who survived longer than five days (p = 0.015, Kruskal-Wallis). The median costs in C-D grades 0, I, II and IV seemed higher in the LVC group, but the differences were not significant between the volume groups (p = 0.377, p = 0.115, p = 0.479, p = 0.821 respectively, Kruskal-Wallis). However, the median costs for patients with grade III complications were the lowest in the HVC group (p = 0.020, Kruskal-Wallis). Table 5. Among patients over 75 years, median costs were lowest in the HVC group (15 DHos in the HVC group and 26 DHos in the MVC group and 20 Dhos in LVC group, p = 0.001, Kruskal-Wallis).

Factors associated with costs in different cost quartiles were analysed with logistic regression analysis considering sex, CCI and operation volume. In the highest cost quartile (>24 DHos) and lowest cost quartile (<11 Dhos) only CCI a significant factor. Significant factors associated with higher than median costs (>15 DHos) comprised operation volume and CCI. Table 6.

Cost-benefit analysis. The difference was also significant when

Table 4
The distribution of resource utilisation did not reach statistical significance.

Resource	HVC	MVC	LVC	p
Number of patients	263	172	31	
Median number of days spent in different health care units	14 (6–90)	16 (3–90)	16 (2–49)	0.213[a]
Clavien-Dindo 0	11 (6–36)	12 (7–37)	15 (6–49)	0.372[a]
Clavien-Dindo 1	12.0 (7–80)	13.0 (9–27)	21 (13–28)	0.259[a]
Clavien-Dindo 2	15 (7–61)	17 (7–72)	195 (9–36)	0.684[a]
Clavien-Dindo 3	20 (8–90)	31 (10–90)	43 (42–48)	0.024[a]
Clavien-Dindo 4	38 (11–90)	36 (13–90)	31 (29–33)	0.951[a]
Median number of days in operating hospital (range)	11 (4–90)	12 (2–90)	12 (2–37)	0.2320[a]
Median number of days in intensive care unit (range)	5.5 (0–31)Ö	4.0 (0–37)ö	2.5 (1–12)ö	0.216[a]
Median number of days in other hospitals (range)	0 (0–56)ö	0 (0–45)ö	0 (0–33)ö	0.089[a]
Median number of days in primary health care facilities (range)	0 (0–63)ö	0 (0–48)ö	0 (0–10)ö	0.244[a]
Number of patients needing additional operations (%)	20 (7.6)	25 (15)	3 (6.3)	0.081[b]
Number of patients needing endoscopies (%)	15 (5.7)	10 (5.8)	1 (3.2)	0.839[b]
Number of patients in radiological drainage (%)	2 (7.6)	13 (7.6)	2 (6.5)	0.973[b]

HVC = high volume centre, MVC = medium volume centre, LVC = low volume centre.
OK!.
[a] Kruskal-Wallis.
[b] Pearson Chi-squared test.

Table 5
Median costs (DHos) after operation.

		HVC	MVC	LVC	p[a]
Total, DHos (range)		14 (6.0–203)	17 (5.5–285)	16 (6–92)	0.019
Complication grade					
	0	10 (6.0–24)	11 (7.0–37)	13 (6.0–49)	0.377
	1	11 (7.0–59)	13 (9.0–27)	21 (13–28)	0.115
	2	15 (7.0–43)	16 (7.0–57)	17.8 (9.0–33)	0.479
	3	21 (9.1–86)	31 (11–100)	46 (40–51)	0.020
	4	62 (19–203)	67 (17–285)	81 (69–92)	0.821

HVC = high volume centre, MVC = median volume centre, LVC = low volume centre.
[a] Kruskal-Wallis.

median costs per survival were calculated (up to 2 years) among cancer patients in C-D classes 0-II (7.0/8.5/10 Dhos in HVCs/MVCs/LVCs; p = 0.005, Kruskal-Wallis). Among C-D classes III-IV differences were insignificant (22/28/26 Dhos in HVCs/MVCs/LVCs; p = 0.535, Kruskal-Wallis). Among patients over 75 years the costs per survival were lowest in HVCs (8.7 Dhos in HVCs vs. 16 and 13 Dhos in MVCs and LVCs, p = 0.009, Kruskal-Wallis).

Discussion

Low postoperative mortality has been widely presented as an advantage after pancreas resection in a HVC [1,3,5,13,14]. This has been related to the failure to rescue concept as well as to hospital characteristics [6,15]. This nation-wide study aimed to assess the effect of operation volume on complications, mortality and cost accumulation of pancreatic resections in Finland. In our study 30-day and 90-day mortality were heavily dependent on operation volume. Although the distribution of other complications showed no significant differences, overall cost accumulation was decidedly lowest in the HVC group, resulting in safe and cost-effective management of patients undergoing pancreatic surgery.

Pancreatic surgery has traditionally been deemed high-risk surgery. Even recently 90–day postoperative mortality rates of 8–10% have been reported [13,16]. Our study showed 90-day mortality of only 1.8% in the HVC group. This is extremely low, but is close to the internationally reported rate of 0–4% in HVCs and in accordance with our results from the period 2002–2008 [1,3,17]. It is interesting that in the HVC group no deaths occurred during the first 20 days after operation, although in lower volume centres patients were lost from the first day onwards. As the complication distribution did not differ, this suggests more successful treatment in the HVC group, and failure to rescue the patients from complications in the MVC and LVC groups. The shortage of means in the surgical, anaesthesiological and interventional radiological treatment of complications may present as increased mortality shortly after the operation.

Analysis of the volume groups showed that, in addition the lower mortality rates in the HVC group, more critically ill patients were also saved. This corroborates the findings of earlier studies reporting an association between failure to rescue and hospital volume [6,17]. Ghaferi et al. [6] reported that patient death was 3.2 times more frequent after a major complication in lower volume centres.

The background of failure to rescue is complex. Sheetz et al. [15] reported that hospital size, occupancy, intensive care availability, teaching status and technology offer a survival advantage for patients undergoing major surgery. The high-volume group in our study comprised the two biggest teaching hospitals in Finland, which perform most of the pancreatic resections and treat most of the critically ill patients in Finland overall. This may give a benefit of experience, which contributes to low postoperative mortality. High operation volumes moreover result in a more uniform surgical technique, which may play a role. Pancreatoduodenectomy was not a standardized procedure in Finland during the study period and the technique depended on the hospital concerned. Wakeam et al. [18] studied secondary complications after surgery and observed wide hospital-level variation in their analysis. It emerged that it is crucial to understand the effect of both structures; the effect of operation volume in general, and the circumstances in individual hospitals.

Although it has been suggested that sufficient volume would result in lower costs in pancreatic surgery [20], the relationship has not been simple to describe [21]. Nathan et al. [21] stated, however, that the better prognosis in HVCs has not been reached with higher costs. In our study the median costs were lowest in the HVC group in all data and in the subgroups. When the costs were adjusted for survival among cancer patients, the costs were interestingly the lowest in C-D grades 0-II in the HVC group. This can be explained by the refined postoperative protocols in HVCs and, of course, potentially longer survival in the HVCs. The volume advantage was not so very obvious in the multivariate analysis, which may have suffered from low statistical power. However, costs lower than the median costs were associated with high operation volume.

The actual rate of yearly pancreatic resection volume is still debatable. The Association of Upper Gastrointestinal Surgeons of Great Britain and Ireland published guidelines on minimum surgeon volumes in 2010 [22] and suggested that the yearly volume of pancreatic resections should be 80–100 resections per year and 12–16 per surgeon per year. Studies concerning surgical performance have also suggested that a sufficient volume per surgeon is related to better outcomes [23,24]. Van der Geest et al. [25] demonstrated in a Dutch study that mortality is lower when the yearly number of PDs is over 40. In our study the hospital volumes ranged from <1 per year to over 60 procedures, thus the cut-offs of 20 for high-volume and 6 for low volume were appropriate for our data.

The strength of this study is that it succeeded in covering data on patients' treatment paths up to 90 days postoperatively and all procedures and ward days are included in the cost analysis. In

Table 6
Logistic regression analysis of factors associated with costs.

Variable		Costs <25% < 11 DHos p	OR (95% COI)	Costs >50% > 15 Dhos p	OR (95% COI)	Costs >75% > 24 Dhos p	OR (95% COI)
Sex	male	reference		reference		reference	
	female	0.918	1.123 (0.438–1.119)	0.157	0.764 (0.527–1.109)	0.165	0.737 (0.819–4.194)
CCI		0.002	0.769 (0.652–0.908)	0.047	1.147 (1.002–1.314)	0.011	1.217 (1.045–1.416)
Operation volume		0.279		0.018		0.080	
	HVC	reference		reference		reference	
	MVC	0.136	0.700 (0.438–1.119)	0.009	1.687 (1.141–2.494)	0.045	1.574 (1.009–2.454)
	LVC	0.785	1.123 (0.489–2.576)	0.105	1.865 (0.878–3.964)	0.139	1.853 (0.819–4.194)

HVC = high volume centre, MVC = median volume centre, LVC = low volume centre, OR = odds ratio, COI = confidence interval, CCI= Charlson comorbidity index.

addition, the study covers all PDs performed nationwide in Finland between 2012 and 2014, affording a good insight into national surgical quality after pancreatic resections. The Finnish registries are considered trustworthy because information on treatment episodes is sent routinely to the national registries at the end of an episode, but the process may naturally be affected by human error. Even though the retrospective nature of our study inevitably leaves some uncertainty in the treatment processes, no patient had to be excluded from the study because of unavailable or missing patient records.

The relative costs used in this study are based on the billing list of one hospital, which facilitated the comparison between different volume groups. However, the effect of fixed costs of a hospital was not evaluated in this study. The evaluation of fixed costs is challenging. First of all it, minimum requirements for a centre performing pancreatic resections should be defined. The pricelist used in this analysis is based on a billing list of a high volume centre offering a wide range of services, also warranted according to a recent review [19].

Because this is a retrospective study, analysing the costs of each care day separately was challenging. This led us to consider other ways to analyse costs of care. In public health care, which is rather based on minimizing of resource utilization than on maximizing profits, a resource based analysis may yield more information on the process than direct comparison of the prices. ERAS-protocol was not a common standard in Finland during the period so this cannot explain the results. We consider that our method is relevant and presents a new insight into cost-effective analysis. Whether the lower costs achieved for pancreas resections in HVCs would also result in lower overall hospital costs is also debatable: the possible savings might just balance the budget among other medical specialities.

In conclusion, short-term prognosis after pancreatic surgery is better when the operation is performed in an HVC. Experience refers not only to surgical experience, but also to the ability of a hospital to avoid failure to rescue. The lower mortality rates are explained by the beneficial rescue protocols after complications in the HVC group. Cost analysis showed significantly lower median costs in the HVC group. Thus pancreatic resections are not only the safest but also the most cost-effective when performed in a high volume centre, thus favouring the centralisation of this demanding type of surgery. We consider the cost-evaluation generalizable especially to other public health care systems.

Conflicts of interest

The authors have no conflicts of interest to declare.

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