Journal of Gastrointestinal Surgery (2019) 23:2081–2092
https://doi.org/10.1007/s11605-019-04215-y

REVIEW ARTICLE

Centralization of Pancreatic Surgery in Europe

Adam Polonski[1] · Jakob R. Izbicki[1,2] · Faik G. Uzunoglu[1]

Received: 19 November 2018 / Accepted: 20 March 2019 / Published online: 29 April 2019

Abstract

Background The objective of this article is a review and an analysis of the current state of centralization of pancreatic surgery in Europe. Numerous recent publications demonstrate higher postoperative in-hospital mortality rates in low-volume clinics after pancreatic resection than previously assumed due to their not publishing significantly worse outcomes when compared to high-volume centres. Although the benefits of centralization of pancreatic surgery in high-volume centres have been demonstrated in many studies, numerous countries have so far failed to establish centralization in their respective health care systems.

Methods A systematic literature search of the Medline database for studies concerning centralization of pancreatic surgery in Europe was conducted. The studies were reviewed independently for previously defined inclusion and exclusion criteria. We included 14 studies with a total of 117,634 patients. All data were extracted from or provided by health insurance company or governmental registry databases.

Results Thirteen out of the 14 studies demonstrate an improvement in their respective outcome related to volume. Twelve studies showed a significantly lower postoperative mortality rate in the highest annual volume group in comparison to overall postoperative mortality rate in the whole patient cohort.

Conclusion As the available data indicate, most European countries have so far failed to establish centralization of pancreatic surgery to high-volume centres due to numerous reasons. Considering a plateau in survival rates of patients undergoing treatment for pancreatic cancer in Europe during the last 15 years, this review enforces the worldwide plea for centralization to lower postoperative mortality after pancreatic surgery.

Keywords Pancreas · Pancreatic surgery · Centralization · Volume-outcome relationship

Introduction

Among all procedures in abdominal surgery, pancreatic surgery has traditionally been considered especially demanding and high-risk. Although at present most procedures are safe, postoperative morbidity and mortality remain high due to complications like haemorrhage or pancreatic fistula. During recent decades, a gradual improvement in the postoperative outcome of pancreatic surgery has been achieved. This development is especially well documented in surgery for pancreatic ductal adenocarcinoma (PDAC).

Despite enormous efforts worldwide, PDAC remains one of the world's deadliest oncological diseases.[1] A recently published study based on discharge data in 59 countries demonstrates a current 5-year survival rate ranging from 5 to 15% between 2000 and 2014, while trends in general survival between 2000 and 2004 and 2010–2014 remained substantially unchanged.[2] So far, pancreatic resection remains the only curative therapeutic option.[3] Although still being considered a high-risk procedure, a relevant decrease in peri-operative morbidity and mortality was reported by numerous specialised centres worldwide.[4–10] This decrease is on the one hand related to improved operative technique, the introduction of surgical checklists, selective patient referral and improved intensive care therapy,[11] but study results have proven that these specialised centres experienced in treating high volumes of PDAC patients have also had a significant impact on the decreasing numbers.

✉ Jakob R. Izbicki
izbicki@uke.de

[1] Department of General, Visceral and Thoracic Surgery, University Medical Centre, Hamburg-Eppendorf, Hamburg, Germany

[2] Department of General Visceral and Thoracic Surgery, University of Hamburg Medical Institutions, Martinistr 52, 20252 Hamburg, Germany

The relation between volume and outcome in pancreatic surgery has been the subject of clinical research for almost 40 years. First studies reach back to 1979,[12] and the subject has been further investigated worldwide ever since. By dividing hospitals into groups of different annual caseloads and creating different annual volume cut-offs, many publications were able to demonstrate a positive effect of performing pancreatic surgery in high-volume centres on postoperative mortality.[13,14] This led to an initiative of centralization of high-risk surgery to high-volume centres, most notably by The Leapfrog Group, a non-profit US-based organisation founded by large employers and other purchasers.[15] In 2000, The Leapfrog Group established minimum annual volume standards for several surgical procedures including pancreatectomy (≥ 11).[16] While further studies were able to show the efficacy of this initiative,[17–21] there is still potential for further improvement. Higher thresholds and minimal caseload requirements for surgeons are currently being debated and have led to the Leapfrog Group establishing new minimum annual hospital- and surgeon-volume standards and procedures for 2018 including pancreatic resection (hospital ≥ 20, surgeon ≥ 10).

Similar efforts are being undertaken in Europe, but only few countries have been able to establish a high degree of centralization to high-volume centres. A recent study conducted in Germany, published by Nimptsch et al., analysing administrative hospital data proves that statistics on pancreatic surgery are not representative for the whole country. The mortality and morbidity rates turned out to be dramatically underestimated.[22] The authors state that the most plausible explanation for the results of the research is the significantly worse outcome in hospitals with low annual caseloads not being reported. Albeit thoroughly researched in the USA, publications on the development and the current state of volume-outcome relation on other continents are scarce. In most of Europe, the process of centralization of high-risk surgery and especially pancreatic surgery is not adequately developed. It does not seem to be a priority on public health makers' agendas due to different political or economic interests. Minimal annual caseloads seem to be interest-based compromises in favour of low-volume centres. Many countries do not research this subject at all, while others provide only few studies.

This review gives a current overview on the volume-outcome relation regarding pancreatic surgery and limiting factors which prevent an effective introduction of its centralization in Europe.

Methods

This review was constructed based on the PRISMA statement.[23] A literature search of the Medline database was conducted (last search on December 28th 2017) using the following "advanced-search" algorithm: "pancreatic surgery" OR "pancreatic resection" OR "pancreatectomy" AND "country" AND "volume" OR "outcome" OR "caseload" OR "requirement" OR "centralization" ("country" being replaced by each European country, i.e. for example "Portugal", "Spain", etc.). The "related articles" feature on PubMed was used, and all included studies were manually cross-referenced for potential articles that were not primarily included. All search results were screened for potential eligibility, and full articles were procured. Only studies investigating postoperative mortality in relation to hospitals with different annual pancreatic surgery caseloads within large patient cohorts were included. Articles written in other languages than English, reviews, abstracts, and articles published more than 10 years ago and single-centre studies were excluded. Literature search was conducted by two authors (AP and FGU) independently, and eligibility of the chosen publications was mutually confirmed. A forest plot was designed to present the search and inclusion process (Fig. 1).

Results

The initial search resulted in 5379 articles matching the chosen search terms. Screening their respective titles led to the exclusion of 5292 articles discussing other subjects. By checking the remaining 87 articles for potentially relevant cross references, 28 further studies were identified which resulted in a total of 115 potential studies. After detailed re-examination, 101 studies were excluded due to irrelevant content or outcome measures for this review ($n = 44$), languages other than English ($n = 15$), being based on single-centred data ($n = 6$), data acquisition by questionnaire or quality control reports ($n = 6$), exclusion of duplicates ($n = 16$), presenting data of non-European countries ($n = 4$), not using volume cut-off points ($n = 4$) or being published before 2005 ($n = 4$). If duplicates of data-samples occurred due to identical data sources ($n = 2$), only the most current study using most recent data was included. All 14 included publications are retrospective cohort studies. In summary, a total of 117,634 patients varying between 467 and 60,858 patients per study underwent elective pancreatic resections in Europe between 1982 and 2014. Data was extracted from or provided by health insurance company databases or governmental registry databases. Mortality was mostly defined as in-hospital mortality ($n = 7$),[24–30] while other authors used 30-day mortality,[31] 90-day mortality,[32] 30- and 90-day mortality,[33] 30- and 60-day mortality,[34] in-hospital and 90-day mortality,[35] in-hospital, 90-day and 1-year mortality,[36] or 90-day and 2-year mortality.[37]

Thirteen out of 14 studies (except Derogar et al.[37]) demonstrate an improvement in their respectively chosen outcome

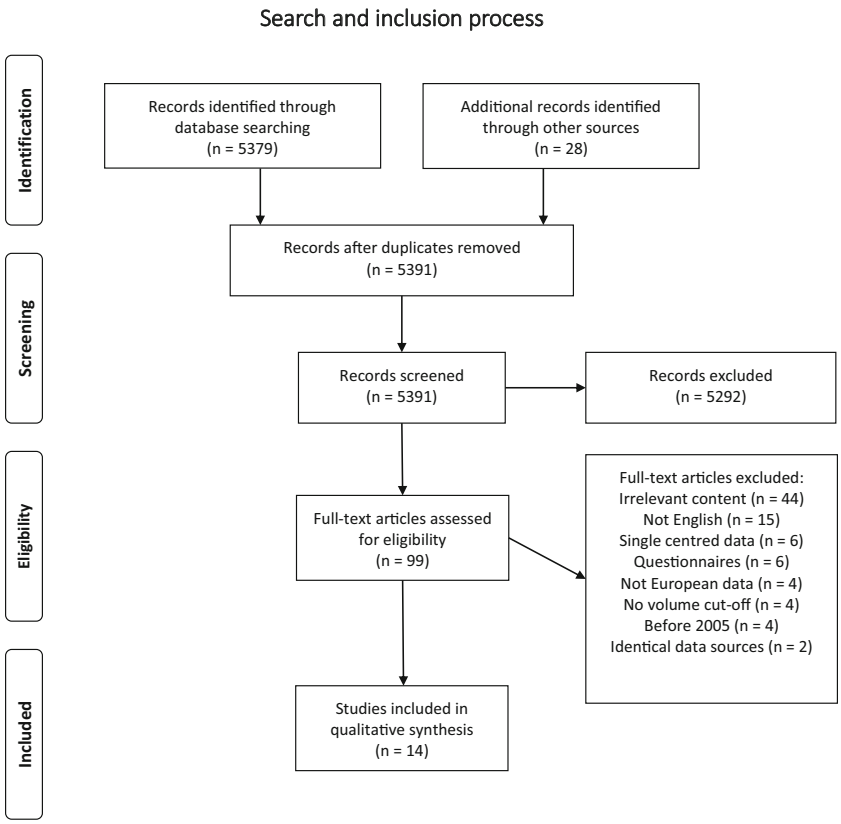

Fig. 1 Forest plot of search and inclusion process

related to volume. In 12 studies (except Derogar et al.[37] and Skipworth et al.[28]), the mortality rate in the highest-volume cut-off group is significantly lower than overall mortality in the whole patient cohort. The detailed data is contained in Table 1.

An analysis of each region/country will be given in the discussion.

Discussion

This review demonstrates several European problems: Centralization is far from being well established, there are great regional differences, and data on the subject are vast. At the same time, this review presents convincing evidence and therefore confirms countless publications: an inverse relation between mortality following pancreatic resection and hospital volume exists regardless of widely differing annual caseload cut-off points. These findings correlate with numerous previously published systematic reviews.[38–43] To put the data into perspective, an interpretation of the presented data in its respective national or regional context might prove useful.

Iberic Peninsula

Pérez et al.[25] demonstrated an inverse relation between patient outcome and hospital volume, while Tebé et al.[24] also showed an ongoing process of centralization in Catalunya. Between 1996 and 2012, the number of hospitals performing pancreatic resections decreased by 32.5%, while patients being treated in high-volume facilities increased from 302 (51%) to 870 (80%). From 2005 to 2012, the overall number of pancreatic resections performed increased by 22.6%. However, Tebé et al. chose the annual cut-off point for high-volume clinics quite low in comparison to the other presented studies (> 10). The study reads, therefore, that the process of centralising pancreatic surgery has yet to be developed adequately in Spain. Appropriately, Hidalgo et al. recently published guidelines for diagnosis, treatment and follow-up of patients with pancreatic cancer in Spain calling for referral of patients with suspected pancreatic malignancies to high-volume centres.[44]

Nordic Countries

Ahola et al.[34] have analysed the development of centralization in Finland. Their main findings are stated in Table 1. Thirty- and 90-day mortality is significantly lower for patients treated in high-volume centres (cut-off point ≥ 20). Even after evening out after 1 year, the survival gap widens again after 2 and 3 years (3-year survival for high-volume centres vs. low-volume centres performing 5 or less pancreatic surgeries per year: 25.4% vs. 14.1%). Despite these facts, the authors state that centralization of pancreatic surgery in Finland might prove extremely difficult or not be practicable at all. Though

Table 1 Characteristics of Included Studies

Authors	Year of publication	Study period	Included patients	Country/ state	Data source	Definition of mortality rate	General Mortality rate(s)	Annual caseload cut-off points	Mortality rates	OR/RR	CI (95%)
Ahola et al. [33]	2017	2002-2008	467	Finland	Finnish Operation and Treatment Register**	30DM	NS	≤5	30DM: 5,5% 90DM: 11%	NS	NS
						60DM	NS			NS	NS
								6 - 19	NS	NS	NS
								≥20	30DM: 0%	NS	NS
									90DM: 2,5%	NS	NS
Farges et al. [34]	2017	2007-2012	22.366	France	3 French diagnosis-related groups: MCO; SSR; HAD	IHM	5,70%	≤25	NS	1,8	1,529 - 2,276
						90DM	8,10%	26 - 65	NS	1,2	1,031 - 1,478
								>65	NS	1	ref
Güller et al. [26]	2017	1999-2012	2.668	Switzerland	Federal Statistic Office Database	IHM	5,20%	1 - 20	5,40%	NS	NS
								≥21	2,00%	NS	NS
Krautz et al. [29]	2017	2009-2014	60.858	Germany	DRG data by Federal and Länder Statistic Offices	IHM	NS	2 - 8	12%	NS	NS
								14 - 18	10,40%	NS	NS
								24 - 31	8,60%	NS	NS
								40 - 58	8,10%	NS	NS
								96 - 134	6,50%	NS	NS
Tebé et al. [23]	2017	1996-2012	2.600	Spain (Catalunya)	Minimum Basic Data Set Of Hospital Discharge	IHM	12%	≤5	NS	1	Ref
							2005-2008: 6%	6 – 10	NS	0,75	0,32 - 1,75
							2009-2012: 6%	>10	NS	0,62	0,31 - 1,25
Alsfasser et al. [35]	2016	2008-2010	9.566	Germany***	German local healthcare funds*	IHM	10,1%	1 – 11	NS	IHM: 2,08	1,44 - 3
						90DM	12,1%			90DM: 1,87	1,35 - 2,6
						1YM	29,8%			1YM: 1,73	1,35 - 2,23
								12 - 21	NS	IHM: 1,65	1,13 - 2,41
										90DM: 1,55	1,11 - 2,17
										1YM: 1,53	1,18 - 1,97
								22 - 34	NS	IHM: 1,42	0,96 - 2,09
										90DM: 1,33	0,94 - 1,89
										1YM: 1,37	1,05 - 1,78

Table 1 (continued)

Authors	Year of publication	Study period	Included patients	Country/ state	Data source	Definition of mortality rate	General Mortality rate(s)	Annual caseload cut-off points	Mortality rates	OR/RR	CI (95%)
								35 - 76	NS	IHM: 1,49	1 - 2,21
										90DM: 1,42	1 - 2,02
										1YM: 1,3	0,99 - 1,7
								77 - 265	NS	IHM: 1	ref
										90DM: 1	ref
										1YM: 1	ref
Pérez et al. [24]	2016	2006-2009	3.164	Spain	Minimum Basic Data Set	IHM	2006-2009: 9,8%	1 – 14	11,90%	1,89	1,29 - 2,75
					Of Hospital Discharge			15 - 31	8,60%	1,21	0,82 - 1,79
								32 - 109	6,20%	1	ref
v.d. Geest et al. [31]	2016	2005-2013	3.420	Netherlands	Netherlands Cancer	90DM	2005: 8,1%	<5	9,70%	1,34	1,09 - 1,65
					Registry		2013: 6,7%	5 – 19	8,90%	1,24	1,09 - 1,42
								20 - 39	7,30%	1,1	0,97 - 1,26
								≥40	4,30%	1	ref
Derogar et al. [36]	2015	1990-2010	3.298	Sweden	Swedish nationwide	90DM	6,9%†	1 – 3	NS	90DM: 1,6	1,04 - 2,48
										2YM: 0,92	0,79 - 1,07
					Registers	2YM	49,2%†	4 – 6	NS	90DM: 1	ref
										2YM: 1	ref
								7 – 9	NS	90DM: 1,12	0,72 - 1,75
										2YM: 1,03	0,84 - 1,26
								10 - 17	NS	90DM: 1,18	0,66 - 2,10
										2YM: 1,09	0,90 - 1,31
								≥18	NS	90DM: 1,18	0,70 - 1,97
										2YM: 1,12	0,90 - 1,47
Gooiker et al. [32]	2014	2000-2009	1.465	Netherlands	Netherlands Cancer Registry	30DM	2005-2009: 4%	1 – 9	30DM: 5,2%	NS	NS
						90DM	2005-2009: 6,3%		90DM: 7,4%		
								10 - 19	30DM: 4,2%	NS	NS
									90DM: 6,5%		
								≥20	30DM: 3,1%	NS	NS
									90DM: 4,8%		

Table 1 (continued)

Authors	Year of publication	Study period	Included patients	Country/ state	Data source	Definition of mortality rate	General Mortality rate(s)	Annual caseload cut-off points	Mortality rates	OR/RR	CI (95%)
Skipworth et al. [27]	2010	1982-2003	1.014	Scotland	Information Services Division Scotland	IHM	8,10%	1	17,50%	NS	NS
								2	10,80%	NS	NS
								3 – 5	5,30%	NS	NS
								≥6	6,90%	NS	NS
Balzano et al. [28]	2008	2003	1.576	Italy	Bureau of Statistics of the Italian Ministry of Health	IHM	8,10%	≤5	NS	1	ref
								6 - 13	NS	0,601	0,385 - 0,938
								14 - 51	NS	0,448	0,280 - 0,715
								89 - 104	NS	0,189	0,075 - 0,476
Pal et al. [30]	2008	1999-2005	3.378	England	Hospital Episode Statistic-derived data	30DM	5,90%	1 - 43	6,50%	NS	NS
								46 - 77	8,00%	NS	NS
								81 - 144	5,40%	NS	NS
								173 - 317	3,80%	NS	NS
Topal et al. [25]	2007	2000-2004	1.794	Belgium	Belgian minimal clinical data set	IHM	8,40%	1 - 2	10,70%	NS	NS
								3 - 5		NS	NS
								6 - 10		NS	NS
								11 - 20	5,40%	NS	NS
								>20		NS	NS

Abbreviations: *OR* Odds Ratio, *RR* Risk Ratio, *CI* Confidence Interval, *ref* reference value, *NS* not stated, *IHM* In-hospital-mortality, *DM* day-mortality, *YM* year-mortality, *DRG* diagnose related groups, *MCO* acute rehabilitation facility, *SSR* subacute-chronic rehabilitation facilities, *HAD* homecare facilities

*Allgemeine Ortskrankenkasse

**HILMO

***limited to 1/3 of the population

†mortality rate calculated from total number of deaths

annual caseloads of 40 pancreatic resections per year might be achievable in the South-West, the overall population density remains low (18 inhabitants per km^2–5 inhabitants per km^2 in the North of Finland) which presents a challenge for health policy makers. The authors suggest centralising pancreatic surgery wherever possible.

A Swedish study describes an ongoing process of centralization of pancreatic cancer surgery in Sweden.[37] Between 1990 and 2010, cases nearly doubled (600 to 1168), while hospitals performing pancreatic surgeries nearly halved (58 to 31). The median annual volume increased from 5 to 16 procedures per year and the proportion of patients undergoing surgery at university hospitals increased from 39 to 66.3%. Between 2005 and 2010, there were still around 50% of surgical treatments undertaken in low-volume centres performing nine or less pancreatic resections annually. The authors state that being treated in a university-hospital has a stronger influence on the outcome than being treated in a high-volume centre. While their presented data supports this theory, one must keep in mind that their chosen annual volume cut-off points are chosen very close to each other and that mortality rates are not divided into time-periods. Thus, a chronologic development can neither be evaluated nor interpreted.

In 2000, Denmark introduced the "National Cancer Plan I" (with an update in 2005) which, among other goals, aimed at improving and accelerating referral pathways and strengthening centralization of cancer surgery. Effects of the initiative were investigated with findings of decreased 30-day mortality rates following pancreas surgery between 1998 (12.2%) and 2009 (5.9%).[45,46]

In Norway, there has not yet been a nationwide analysis based on discharge data. Only Soreide et al. published a study on the effect of increasing volume in their hospital in Stavanger.[47] Between 1986 and 2012, 219 patients underwent pancreatic surgery. From 1986 to 1995, there were 35 procedures with a 30-day mortality rate of 14.3%. From 2006 to 2012, there were 95 procedures with a 30-day mortality rate of 6.3%. Annual caseload increased from one pancreatic resection in 1986 to a maximum of 18 in 2006. The authors state that while increased hospital volume might also be an important factor for this improvement in outcome, there are certainly others: improved imaging, pre-operative evaluation, perioperative care and patient selection.

In Iceland, Jonsdottir et al. investigated the outcome of PDAC therapy between 1986 and 2007.[48] The incidence of PDAC remained fairly stable during both time periods chosen (1986–1997 and 1998–2009), while 6-month and 1-year survival significantly improved. Due to pancreatic cancer surgery in Iceland being performed solely in one clinic in Reykjavik during the investigated period, the effect cannot be related to a centralization of pancreatic surgery.

To our knowledge, the degree of centralization in some Nordic countries has substantially improved in the last period. However, current data were unfortunately not available.

UK

In 1995, Bramhall et al.[49] published an epidemiological study based on the surveillance data held at the West Midlands Region Cancer Registry. The authors compared two patient cohorts undergoing treatment for pancreatic cancer in two different time periods. The 30-day mortality rate after pancreatic resections between 1957 and 1976 was 45.2% and dropped to 27.6% between 1977 and 1986. While significantly decreased, these mortality rates were still much higher than those from published single hospital series in the area in the same period and therefore failed to be seen as representative.[50]

In 2001, the Association of Upper Gastrointestinal Surgeons of Great Britain and Ireland and the UK Health Department stated that all patients with pancreatic cancer should be treated in specialist units serving populations of 2 to 4 million. As shown in both included UK-based studies, this drastic measurement was efficient: 30-day mortality in England decreased from 6.2 to 5.7% between 1999 and 2005, while hospitals performing pancreatic resections decreased from 101 to 73 and annual cases increased from 1473 to 1905.[31] In Scotland, the percentage of procedures performed in high-volume units increased significantly between 1982 and 2003.[28] In-hospital mortality was lowest in high-volume units. This might have been even more evident if the authors had decided to determine a higher cut-off point for high-volume units than ≥ 6 procedures per year. In context of current literature on the subject, this number is very low. Another Scottish publication confirmed the presence of centralization in Scotland and demonstrated a significant decrease in adverse events.[51]

France

Farges et al.[35] investigated the current situation in France. Between 2007 and 2012, 56% of all patients undergoing surgery were operated at 456 units performing 25 or less pancreatic resections per year, while 23% were operated at 9 clinics performing more than 65 procedures a year. A centralization process was confirmed: Units performing more than 25 procedures annually increased from 5.1 to 7.6%, and patient percentages treated in these facilities increased from 39.6 to 48.6%. Low volume units decreased from 213 to 167. The authors state that centralization to centres performing 65 or more procedures per year is currently hardly feasible due to high-volume units being limited in number and unevenly distributed throughout France. Also, they state that one third of administrative regions are unable to cope with the demand in terms of pancreatic resections due to insufficient health supply. Farges et al. reason that a further difficulty lies within the health system itself—hospitals are being paid for their performances and are therefore understandably not eager to renounce pancreatic surgery.

Switzerland and Austria

Güller et al.[27] investigated the state of pancreatic surgery in Switzerland between 1999 and 2012. The authors demonstrate that between 2009 and 2012, only 14.8% of all patients undergoing pancreatic resections were operated at facilities performing 21 or more procedures per year. These patients had an in-hospital mortality rate of 2% in contrast to patients who were operated in facilities with smaller annual caseloads (5%). Accordingly, since January 1, 2018, pancreatic surgery may now only be performed in centres performing at least 20 resections annually.[52]

No Austrian publications investigating large patient cohorts based on discharge data were found during our research. Since 2011, pancreatic surgery is restricted to centres performing 10 or more pancreatic resections annually.[53] The effect of this measurement is yet to be investigated.

Benelux

In 2007, there was no evidence of centralization in Belgium between 2000 and 2004. Pancreatic surgery was performed in 126 hospitals, most of them being low-volume units performing 10 or less procedures per year. Topal et al. state that a minimal annual caseload of 10 pancreatoduodenectomies would culminate in a centralization of surgery from 126 to 7 hospitals and mortality could be decreased from 8.4 to 6%.[26] There were no data found regarding the following development.

The situation in the Netherlands on the other hand is very well documented. A plea for centralization has been ongoing since 1994 as mortality rate after pancreatic surgery proved to be surprisingly high.[38] Before introducing official thresholds by health policy makers, regional hospitals cooperated to simulate centralization on a regional level.[54,55] Publications based on discharge data confirmed the efficacy of this initiative by demonstrating a decrease of in-hospital mortality from 9.8 to 5.1% between 2004 and 2009, while hospitals performing pancreatic surgery decreased from 48 to 30 and percentage of patients undergoing surgery in high- or medium-volume units increased from 53 to 91%.[56,57] Based on these findings, in 2011, the Dutch Society of Surgeons and the Dutch healthcare suggested a minimal annual caseload of 20 pancreatoduodenectomies per centre during a period of three consecutive years.[58] Subsequently, there was an even greater decrease in clinics performing pancreatic resections (42 to 21), the median annual caseload increased (4 to 23) and percentage of patients treated in facilities performing more than 40 pancreatic procedures per year increased from 14 to 36%.[32] These findings suggest that even in a centralised country like the Netherlands, there is potential for better outcome if annual caseload requirements were to be increased. An optimal threshold of excellence is yet to be defined. In 2013, the Dutch Pancreatic Cancer Audit was founded as a tool to measure and compare the outcome in the Netherlands. In 2014 and 2015, the nationwide mortality rate after pancreatic resections was 3.6%.[59] Apart from a decrease in general mortality rate, van der Geest et al.[58] demonstrated a major benefit for elderly patients (≥ 75 years). As procedures performed on elderly patients often become high-risk procedures due to higher rates of co-morbidities and decreased physiologic reserve, mortality is twice as high as in younger patients when treated in low-volume hospitals (1–14 cases/year). That difference was less pronounced in high-volume centres (≥ 29 cases/year). Overall, the mortality rate in elderly patients decreased between 2005 and 2013 from 10.2 to 5.1%, while the percentage of elderly patients treated in high-volume centres increased (2005: 17%; 2013: 50%).[58] The excellent outcome of this initiative has led to a further debate on increasing the threshold to 40 or even 60 annual pancreatectomies.

Italy

Balzano et al.[29] demonstrate that overall in-hospital mortality in 2003 in Italy is 8.1%. However, when comparing different annual volume cut-offs, there are massive discrepancies: in-hospital mortality in low-volume centres performing 5 or less pancreatic resections is as high as 12.4% and only 2.6% in the two highest-volume centres in Italy. The post-operative stay in high-volume centres was significantly lower. Centralization of all resections to those two clinics might have prevented 87 deaths. Seventy-five percent of Italian clinics were still low-volume centres treating one third of the Italian population. Despite a plea for centralization, criteria published to identify adequate hospitals to perform pancreatic resections[60] and a recent review on the latest evidence concerning therapy of PDAC including centralization,[61] Stella et al.[62] claim that a centralised model in Italy might be difficult to introduce due to socioeconomic factors.

Germany

As stated in the introduction, single-centre studies have been published during the last decades suggesting that the outcome after pancreatic surgery in Germany is acceptable or even excellent. This, however, is not the case nationwide, and the situation is comparable to the data for the West Midlands in the UK.[49]

Based on a third of Germany's population, Alsfasser et al.[36] reported an in-hospital mortality of 10.1% following pancreatic resections. This was confirmed in 2016 based on diagnosis-related group data from 2009 to 2013.[22] This unexpectedly high mortality rate might be explained by insufficient centralization. Twenty-five percent of German hospitals perform one or two pancreatic resections per year. Risk-adjusted mortality in these low-volume clinics was 11.5% in contrast to 6.5% in high-volume clinics (96–134 cases per year).

Mortality following septic complications was higher in low-volume units (36.8% vs 24.2%). Furthermore, high-volume units had lower rates of intervention for complication (i.e. blood transfusion or prolonged mechanical ventilation) and a shorter length of stay. By concentrating low-volume clinics (2–18 cases/year) to high-volume clinics in a hypothetical model simulating centralization, 94 deaths per year could be prevented.[30] Possible reasons for the evident lack of centralization in Germany are multi-factorial. Firstly, Germany is facing a failure of its health policy. There is a minimal annual caseload requirement for pancreatic surgeries of 10 resections per year. In comparison with the UK or the Netherlands where the process of centralization is far more advanced, this seems a very low threshold. In addition, this regulation is not being enforced. Hospitals not achieving the minimal caseload requirement hardly suffer any economic consequences.[63] Secondly, there is a structural problem. There are a lot of small unspecialized clinics unevenly distributed throughout the whole country creating overcapacities. The Hamburg metropolitan area for instance, home-base for our high-volume centre, being inhabited by 5 million people has 9 hospitals performing pancreatic surgery. These circumstances would be impossible in the Netherlands or the UK. In Germany, these hospitals continue performing highly specialised procedures due to economic reasons and possibly due to reputational reasons: Pancreatic surgery remains one of general surgery's supreme disciplines, not likely to be renounced by many surgeons.

During the recent development process of updated guidelines for the therapy of pancreatic cancer in Germany, a proposition to make it mandatory for low-volume centres to obtain a second opinion from high-volume centres concerning the resectability of locally advanced pancreatic tumours was rejected.

Three steps are imperative towards the introduction of centralization in Germany: a significant raise of the annual minimal caseload, consequent enforcement of these regulations and no granting of exceptions.

Centralization in Europe

While all publications included in this review and all publications mentioned in the discussion are extremely heterogenous concerning time periods, number of patients included, outcome definition and volume cut-off points and therefore hard to compare, there is unequivocal evidence that patients benefit from centralization of pancreatic surgery. The strength of this study is the fact that the findings of all included studies are based on discharge or insurance company data. We are aware that including only 14 studies from 11 out of 44 European countries might limit this manuscript's representativity, but we wanted to ensure that patient cohorts are preferably large and selection bias therefore unlikely despite all studies being retrospective. To our knowledge, this is the first review describing the current state of centralization of pancreatic surgery in Europe.

Our findings also show that there is a significant potential for further improvement. The UK and especially the Netherlands are great role models for how the introduction of centralization might work. While the UK utilised a top-down method by introducing strict thresholds for pancreatic surgery centres, the Netherlands chose a different approach. At the beginning of the process, several clinics cooperated to introduce centralization regionally and published their promising improvement of outcome creating pressure on health policy makers. After introduction of thresholds, further research was conducted and further steps were taken towards centralization. The effect is impressive: During a decade, in-hospital mortality rate after pancreatic resections decreased from 9.8 to 3.6% nationwide. Clearly, there are other factors also responsible for the better outcome after pancreatic surgery: technological advances, better peri-operative care (especially intensive care) or improved hospital safety standards. The impact of surgeon volume and expertise rather than hospital volume is currently being controversially debated.[10, 64–67] Even though these stated factors might contribute to better patient outcome, it seems highly unlikely that their role outstands that of hospital-volume.

Compared to more or less "uncentralized" countries like Germany, the Netherlands simply perform too well to allow a disregard of the benefits of centralization.

However, drawbacks of the process of centralization, i.e. its structural limitations, must equally be named. The main difficulty is that introducing the process is only practicable in densely inhabited areas and in centres offering multidisciplinary cooperative treatment. In some areas, patients might have to travel long distances and might not be up for treatment far away from their homes and families. Finally, there also exists the danger of case numbers increasing, resulting in long waiting list for patients. Long-term effects remain to be investigated in all involved countries.

Considering all of the above, the question arises why centralization of pancreatic surgery has not been established throughout all of Europe? Our review provides possible answers: structure of health-care-system and unevenly distributed high-volume centres (Germany and France), low population density (Finland), socioeconomic factors or inefficient enforcement of minimal caseload regulations as well as reputational reasons (Germany). The reasons are individual and specific for each country. This is what makes creating a universal plan of action difficult if not impossible even though it would be of great interest to the cause of centralization. Each country needs to address the issue individually in order to solve it effectively.

Unfortunately, there were no English language publications available provided by Eastern European countries.

If centralization does not seem feasible, alternatives are being considered. Two studies suggest that if chief surgeons shared the same mentor or if a surgeon had a previous high-volume surgical experience, similar outcomes in low-volume centres can be achieved.[62,68] Another option would be a "high-volume surgeon" travelling to low-volume institutions to perform surgery. While maybe applicable for the surgical procedure itself, we do not believe that these measurements would overcome differences in failure-to-rescue between high-volume and low-volume units. Perioperative care of patients undergoing pancreatic surgery is a matter of interdisciplinary cooperation within highly experienced teams. Institutions which cannot provide 24-h access to endoscopy, interventional radiology and ICU that should not perform pancreatic procedures. Furthermore, a good quality in nursing and physical therapy are important factors for fast postoperative recovery. Enhanced recovery after surgery ("ERAS") is a subject which is currently being investigated in a lot of high-volume centres worldwide.[69]

These alternatives should be considered but only where the process of centralization cannot be introduced at all (for example in scarcely populated areas). Otherwise, in our opinion, centralization should be applied wherever possible as there is no adequate alternative.

Conclusion

According to findings all over the world including Europe, centralization of pancreatic surgery leads to lower mortality. Despite a few deficiencies (only feasible in centres with multidisciplinary care, travel burden for patients, hardly practicable in low population density areas, possibility of waiting lists), it presents a simple but effective method to radically lower in-hospital mortality rates all over Europe. As recently shown by Allemani et al., general survival rates of patients undergoing pancreatic surgery and especially PDAC patients seem to have reached a plateau in Europe during the last 15 years.[2] Therefore, any step necessary and possible to even slightly improve survival rates and reduce post-operative mortality should be taken. However, except for the Netherlands and the UK, we are not nearly where we need to be. Enormous efforts need to be made across Europe in order to improve the current situation. We need more data, more research, more medial campaigning, more pressure on health policy makers. Surgeons and consequently surgical societies should take the lead in defining basic requirements of high-volume centres in Europe including standard quality metrics of early postoperative outcome, presence of ICU, capacity for interdisciplinary treatment, institutional 24-h access to endoscopy and interventional radiology and close postoperative out-patient care of the high-volume centres. The recently published special lecture on centralization of gastrointestinal surgery given at the annual ESA meeting 2018 is an ideal example: leading European surgeons joined forces and made a strong statement "Toward a Consensus on Centralization of Surgery".[70]

Considering Krautz et al.'s statement that centralization of pancreatic surgery might prevent 94 deaths per year in Germany alone, there is only one way to conclude: Centralization of pancreatic surgery is long overdue!

References

1. Ilic M, Ilic I. Epidemiology of pancreatic cancer. World J Gastroenterol 2016;22:9694–705. https://doi.org/10.3748/wjg.v22.i44.9694.
2. Allemani C, Matsuda T, Carlo VD, Harewood R, Matz M, Nikšić M, et al. Global surveillance of trends in cancer survival 2000–14 (CONCORD-3): analysis of individual records for 37 513 025 patients diagnosed with one of 18 cancers from 322 population-based registries in 71 countries. Lancet 2018 https://doi.org/10.1016/S0140-6736(17)33326-3.
3. Doi R, Imamura M, Hosotani R, Imaizumi T, Hatori T, Takasaki K, et al. Surgery versus radiochemotherapy for resectable locally invasive pancreatic cancer: final results of a randomized multi-institutional trial. Surg Today 2008;38:1021–8. https://doi.org/10.1007/s00595-007-3745-8.
4. Büchler MW, Wagner M, Schmied BM, Uhl W, Friess H, Z'graggen K. Changes in morbidity after pancreatic resection: toward the end of completion pancreatectomy. Arch Surg Chic Ill 1960 2003;138:1310–4; discussion 1315. https://doi.org/10.1001/archsurg.138.12.1310.
5. Distler M, Rückert F, Hunger M, Kersting S, Pilarsky C, Saeger H-D, et al. Evaluation of survival in patients after pancreatic head resection for ductal adenocarcinoma. BMC Surg 2013;13:12. https://doi.org/10.1186/1471-2482-13-12.
6. Parikh P, Shiloach M, Cohen ME, Bilimoria KY, Ko CY, Hall BL, et al. Pancreatectomy risk calculator: an ACS-NSQIP resource. HPB 2010;12:488–97. https://doi.org/10.1111/j.1477-2574.2010.00216.x.
7. Uzunoglu FG, Reeh M, Vettorazzi E, Ruschke T, Hannah P, Nentwich MF, et al. Preoperative Pancreatic Resection (PREPARE) score: a prospective multicenter-based morbidity risk score. Ann Surg 2014;260:857–63; discussion 863-864. https://doi.org/10.1097/SLA.0000000000000946.
8. Grützmann R, Rückert F, Hippe-Davies N, Distler M, Saeger H-D. Evaluation of the International Study Group of Pancreatic Surgery definition of post-pancreatectomy hemorrhage in a high-volume center. Surgery 2012;151:612–20. https://doi.org/10.1016/j.surg.2011.09.039.
9. Keck T, Wellner UF, Bahra M, Klein F, Sick O, Niedergethmann M, et al. Pancreatogastrostomy Versus Pancreatojejunostomy for RECOnstruction After PANCreatoduodenectomy (RECOPANC, DRKS 00000767). Ann Surg 2016;263:440–9. https://doi.org/10.1097/SLA.0000000000001240.
10. Schmidt CM, Turrini O, Parikh P, House MG, Zyromski NJ, Nakeeb A, et al. Effect of hospital volume, surgeon experience, and surgeon volume on patient outcomes after pancreaticoduodenectomy: a single-institution experience. Arch Surg Chic Ill 1960 2010;145:634–40. https://doi.org/10.1001/archsurg.2010.118.
11. Birkmeyer JD. Progress and challenges in improving surgical outcomes. Br J Surg 2012;99:1467–9. https://doi.org/10.1002/bjs.8933.

12. Luft HS, Bunker JP, Enthoven AC. Should operations be regionalized? The empirical relation between surgical volume and mortality. N Engl J Med 1979;301:1364–9. https://doi.org/10.1056/NEJM197912203012503.
13. Birkmeyer JD, Siewers AE, Finlayson EVA, Stukel TA, Lucas FL, Batista I, et al. Hospital Volume and Surgical Mortality in the United States. N Engl J Med 2002;346:1128–37. https://doi.org/10.1056/NEJMsa012337.
14. McPhee JT, Hill JS, Whalen GF, Zayaruzny M, Litwin DE, Sullivan ME, et al. Perioperative Mortality for Pancreatectomy. Ann Surg 2007;246:246–53. https://doi.org/10.1097/01.sla.0000259993.17350.3a.
15. Leapfrog. Leapfrog n.d. http://www.leapfroggroup.org/. Accessed January 22, 2018.
16. Milstein A, Galvin RS, Delbanco SF, Salber P, Buck CR. Improving the safety of health care: the leapfrog initiative. Eff Clin Pract ECP 2000;3:313–6.
17. Finks JF, Osborne NH, Birkmeyer JD. Trends in Hospital Volume and Operative Mortality for High-Risk Surgery. N Engl J Med 2011;364:2128–37. https://doi.org/10.1056/NEJMsa1010705.
18. Ghaferi AA, Birkmeyer JD, Dimick JB. Hospital volume and failure to rescue with high-risk surgery. Med Care 2011;49:1076–81. https://doi.org/10.1097/MLR.0b013e3182329b97.
19. Reames BN, Ghaferi AA, Birkmeyer JD, Dimick JB. Hospital Volume and Operative Mortality in the Modern Era. Ann Surg 2014;260:244–51. https://doi.org/10.1097/SLA.0000000000000375.
20. Sahni NR, Dalton M, Cutler DM, Birkmeyer JD, Chandra A. Surgeon specialization and operative mortality in United States: retrospective analysis. BMJ 2016;354. https://doi.org/10.1136/bmj.i3571.
21. Kagedan DJ, Goyert N, Li Q, Paszat L, Kiss A, Earle CC, et al. The Impact of Increasing Hospital Volume on 90-Day Postoperative Outcomes Following Pancreaticoduodenectomy. J Gastrointest Surg Off J Soc Surg Aliment Tract 2017;21:506–15. https://doi.org/10.1007/s11605-016-3346-1.
22. Nimptsch U, Krautz C, Weber GF, Mansky T, Grützmann R. Nationwide In-hospital Mortality Following Pancreatic Surgery in Germany is Higher than Anticipated. Ann Surg 2016;264:1082–90. https://doi.org/10.1097/SLA.0000000000001693.
23. Moher D, Liberati A, Tetzlaff J, Altman DG, PRISMA Group. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. Ann Intern Med 2009;151:264–9, W64.
24. Tebé C, Pla R, Espinàs JA, Corral J, Puigdomenech E, Borràs JM, et al. Towards the centralization of digestive oncologic surgery: changes in activity, techniques and outcome. Rev Espanola Enfermedades Dig Organo Of Soc Espanola Patol Dig 2017;109:634–42. https://doi.org/10.17235/reed.2017.4710/2016.
25. Pérez-López P, Baré M, Touma-Fernández Á, Sarría-Santamera A. Relationship between volume and in-hospital mortality in digestive oncological surgery. Cirugia Espanola 2016;94:151–8. https://doi.org/10.1016/j.ciresp.2015.09.005.
26. Topal B, Van de Sande S, Fieuws S, Penninckx F. Effect of centralization of pancreaticoduodenectomy on nationwide hospital mortality and length of stay. Br J Surg 2007;94:1377–81. https://doi.org/10.1002/bjs.5861.
27. Güller U, Warschkow R, Ackermann CJ, Schmied BM, Cerny T, Ess S. Lower hospital volume is associated with higher mortality after oesophageal, gastric, pancreatic and rectal cancer resection n.d.. https://doi.org/10.4414/smw.2017.14473.
28. Skipworth RJE, Parks RW, Stephens NA, Graham C, Brewster DH, Garden OJ, et al. The relationship between hospital volume and post-operative mortality rates for upper gastrointestinal cancer resections: Scotland 1982–2003. Eur J Surg Oncol EJSO 2010;36:141–7. https://doi.org/10.1016/j.ejso.2009.10.004.
29. Balzano G, Zerbi A, Capretti G, Rocchetti S, Capitanio V, Di Carlo V. Effect of hospital volume on outcome of pancreaticoduodenectomy in Italy. Br J Surg 2008;95:357–62. https://doi.org/10.1002/bjs.5982.
30. Krautz C, Nimptsch U, Weber GF, Mansky T, Grützmann R. Effect of Hospital Volume on In-hospital Morbidity and Mortality Following Pancreatic Surgery in Germany. Ann Surg 2017. https://doi.org/10.1097/SLA.0000000000002248.
31. Pal N, Axisa B, Yusof S, Newcombe RG, Wemyss-Holden S, Rhodes M, et al. Volume and Outcome for Major Upper GI Surgery in England. J Gastrointest Surg 2008;12:353–7. https://doi.org/10.1007/s11605-007-0288-7.
32. van der Geest LGM, van Rijssen LB, Molenaar IQ, de Hingh IH, Groot Koerkamp B, Busch ORC, et al. Volume-outcome relationships in pancreatoduodenectomy for cancer. HPB 2016;18:317–24. https://doi.org/10.1016/j.hpb.2016.01.515.
33. Gooiker GA, Lemmens VEPP, Besselink MG, Busch OR, Bonsing BA, Molenaar IQ, et al. Impact of centralization of pancreatic cancer surgery on resection rates and survival. Br J Surg 2014;101:1000–5. https://doi.org/10.1002/bjs.9468.
34. Ahola R, Siiki A, Vasama K, Vornanen M, Sand J, Laukkarinen J. Effect of centralization on long-term survival after resection of pancreatic ductal adenocarcinoma. Br J Surg 2017;104:1532–8. https://doi.org/10.1002/bjs.10560.
35. Farges O, Bendersky N, Truant S, Delpero JR, Pruvot FR, Sauvanet A. The Theory and Practice of Pancreatic Surgery in France. Ann Surg 2017;266:797–804. https://doi.org/10.1097/SLA.0000000000002399.
36. Alsfasser G, Leicht H, Günster C, Rau BM, Schillinger G, Klar E. Volume-outcome relationship in pancreatic surgery. Br J Surg 2016;103:136–43. https://doi.org/10.1002/bjs.9958.
37. Derogar M, Blomberg J, Sadr-Azodi O. Hospital teaching status and volume related to mortality after pancreatic cancer surgery in a national cohort. Br J Surg 2015;102:548–57. https://doi.org/10.1002/bjs.9754.
38. van Heek NT, Kuhlmann KFD, Scholten RJ, de Castro SMM, Busch ORC, van Gulik TM, et al. Hospital volume and mortality after pancreatic resection: a systematic review and an evaluation of intervention in the Netherlands. Ann Surg 2005;242:781–8, discussion 788-790.
39. Gooiker GA, van Gijn W, Wouters MWJM, Post PN, van de Velde CJH, Tollenaar R EM, et al. Systematic review and meta-analysis of the volume-outcome relationship in pancreatic surgery. Br J Surg 2011;98:485–94. https://doi.org/10.1002/bjs.7413.
40. Krautz C, Denz A, Weber GF, Grützmann R. Influence of Hospital Volume Effects and Minimum Caseload Requirements on Quality of Care in Pancreatic Surgery in Germany. Visc Med 2017;33:131–4. https://doi.org/10.1159/000456042.
41. La Torre M, Nigri G, Ferrari L, Cosenza G, Ravaioli M. Hospital volume, margin status, and long-term survival after pancreaticoduodenectomy for pancreatic adenocarcinoma. Am Surg 2012;78:225–9.
42. Killeen SD, O'Sullivan MJ, Coffey JC, Kirwan WO, Redmond HP. Provider volume and outcomes for oncological procedures. Br J Surg 2005;92:389–402. https://doi.org/10.1002/bjs.4954.
43. Hata T, Motoi F, Ishida M, Naitoh T, Katayose Y, Egawa S, et al. Effect of Hospital Volume on Surgical Outcomes After Pancreaticoduodenectomy: A Systematic Review and Meta-analysis. Ann Surg 2016;263:664–72. https://doi.org/10.1097/SLA.0000000000001437.
44. Hidalgo M, Álvarez R, Gallego J, Guillén-Ponce C, Laquente B, Macarulla T, et al. Consensus guidelines for diagnosis, treatment and follow-up of patients with pancreatic cancer in Spain. Clin Transl Oncol 2017;19:667–81. https://doi.org/10.1007/s12094-016-1594-x.

45. Cronin-Fenton DP, Erichsen R, Mortensen FV, Dikinis S, Nørgaard M, Jacobsen J. Pancreatic cancer survival in central and northern Denmark from 1998 through 2009: a population-based cohort study. Clin Epidemiol 2011;3 Suppl 1:19–25. https://doi.org/10.2147/CLEP.S20611.
46. Storm HH, Gislum M, Engholm G. [Cancer survival before and after initiating the Danish Cancer Control plan]. Ugeskr Laeger 2008;170:3065–9.
47. Søreide JA, Sandvik OM, Søreide K. Improving pancreas surgery over time: Performance factors related to transition of care and patient volume. Int J Surg 2016;32:116–22. https://doi.org/10.1016/j.ijsu.2016.06.046.
48. Jonsdottir SB, Juliusson G, Kristinsson JÖ, Hreinsson JP, Jonasson JG, Björnsson ES. Incidence, diagnostic, treatment and outcome of patients diagnosed with cancer of the pancreas during 1986-2009: a population-based study. Scand J Gastroenterol 2018;53:100–6. https://doi.org/10.1080/00365521.2017.1390598.
49. Bramhall SR, Allum WH, Jones AG, Allwood A, Cummins C, Neoptolemos JP. Treatment and survival in 13,560 patients with pancreatic cancer, and incidence of the disease, in the West Midlands: an epidemiological study. Br J Surg 1995;82:111–5.
50. Watanapa P, Williamson RC. Surgical palliation for pancreatic cancer: developments during the past two decades. Br J Surg 1992;79:8–20.
51. Young J, Thompson A, Tait I, Waugh L, McPhillips G. Centralization of Services and Reduction of Adverse Events in Pancreatic Cancer Surgery. World J Surg 2013;37:2229–33. https://doi.org/10.1007/s00268-013-2108-4.
52. GDK - Schweizerische Konferenz der kantonalen Gesundheitsdirektorinnen und -direktoren: Hochspezialisierte Medizin n.d. https://www.gdk-cds.ch/index.php?id=822. Accessed January 30, 2018.
53. Gangl O, Sahora K, Kornprat P, Margreiter C, Primavesi F, Bareck E, et al. Preparing for Prospective Clinical Trials: A National Initiative of an Excellence Registry for Consecutive Pancreatic Cancer Resections. World J Surg 2014;38:456–62. https://doi.org/10.1007/s00268-013-2283-3.
54. Nienhuijs SW, Rutten HJT, Luiten EJT, van Driel OJR, Reemst PHM, Lemmens VEPP, et al. Reduction of in-hospital mortality following regionalisation of pancreatic surgery in the south-east of the Netherlands. Eur J Surg Oncol J Eur Soc Surg Oncol Br Assoc Surg Oncol 2010;36:652–6. https://doi.org/10.1016/j.ejso.2010.05.008.
55. .Lemmens VEPP, Bosscha K, van der Schelling G, Brenninkmeijer S, Coebergh JWW, de Hingh IHJT. Improving outcome for patients with pancreatic cancer through centralization. Br J Surg 2011;98:1455–62. https://doi.org/10.1002/bjs.7581.
56. Gooiker GA, van der Geest LGM, Wouters MWJM, Vonk M, Karsten TM, Tollenaar RAEM, et al. Quality improvement of pancreatic surgery by centralization in the western part of the Netherlands. Ann Surg Oncol 2011;18:1821–9. https://doi.org/10.1245/s10434-010-1511-4.
57. de Wilde RF, Besselink MGH, van der Tweel I, de Hingh IHJT, van Eijck CHJ, Dejong CHC, et al. Impact of nationwide centralization of pancreaticoduodenectomy on hospital mortality. Br J Surg 2012;99:404–10. https://doi.org/10.1002/bjs.8664.
58. van der Geest LGM, Besselink MGH, Busch ORC, de Hingh IHJT, van Eijck CHJ, Dejong CHC, et al. Elderly Patients Strongly Benefit from Centralization of Pancreatic Cancer Surgery: A Population-Based Study. Ann Surg Oncol 2016;23:2002–9. https://doi.org/10.1245/s10434-016-5089-3.
59. van Rijssen LB, Koerkamp BG, Zwart MJ, Bonsing BA, Bosscha K, van Dam RM, et al. Nationwide prospective audit of pancreatic surgery: design, accuracy, and outcomes of the Dutch Pancreatic Cancer Audit. HPB 2017;19:919–26. https://doi.org/10.1016/j.hpb.2017.06.010.
60. Bassi C, Balzano G, Zerbi A, Ramera M. Pancreatic surgery in Italy. Criteria to identify the hospital units and the tertiary referral centers entitled to perform it. Updat Surg 2016;68:117–22. https://doi.org/10.1007/s13304-016-0371-2.
61. Maggino L, Vollmer CM. Recent Advances in Pancreatic Cancer Surgery. Curr Treat Options Gastroenterol 2017;15:520–37. https://doi.org/10.1007/s11938-017-0150-2.
62. Stella M, Bissolati M, Gentile D, Arriciati A. Impact of surgical experience on management and outcome of pancreatic surgery performed in high- and low-volume centers. Updat Surg 2017;69:351–8. https://doi.org/10.1007/s13304-017-0422-3.
63. Geraedts M, Kühnen C, Cruppé W de, Blum K, Ohmann C. [Hospitals failing minimum volumes in 2004: reasons and consequences]. Gesundheitswesen Bundesverb Arzte Offentlichen Gesundheitsdienstes Ger 2008;70:63–7. https://doi.org/10.1055/s-2007-1022522.
64. Jeganathan R, Kinnear H, Campbell J, Jordan S, Graham A, Gavin A, et al. A surgeon's case volume of oesophagectomy for cancer does not influence patient outcome in a high volume hospital. Interact Cardiovasc Thorac Surg 2009;9:66–9. https://doi.org/10.1510/icvts.2008.195461.
65. Migliore M, Choong CK, Lim E, Goldsmith KA, Ritchie A, Wells FC. A surgeon's case volume of oesophagectomy for cancer strongly influences the operative mortality rate. Eur J Cardiothorac Surg 2007;32:375–80. https://doi.org/10.1016/j.ejcts.2007.04.014.
66. Pecorelli N, Balzano G, Capretti G, Zerbi A, Di Carlo V, Braga M. Effect of surgeon volume on outcome following pancreaticoduodenectomy in a high-volume hospital. J Gastrointest Surg Off J Soc Surg Aliment Tract 2012;16:518–23. https://doi.org/10.1007/s11605-011-1777-2.
67. Mamidanna R, Ni Z, Anderson O, Spiegelhalter SD, Bottle A, Aylin P, et al. Surgeon Volume and Cancer Esophagectomy, Gastrectomy, and Pancreatectomy: A Population-based Study in England. Ann Surg 2016;263:727–32. https://doi.org/10.1097/SLA.0000000000001490.
68. Capretti G, Balzano G, Gianotti L, Stella M, Ferrari G, Baccari P, et al. Management and Outcomes of Pancreatic Resections Performed in High-Volume Referral and Low-Volume Community Hospitals Lead by Surgeons Who Shared the Same Mentor: The Importance of Training. Dig Surg 2018;35:42–8. https://doi.org/10.1159/000464412.
69. Lassen K, Coolsen MME, Slim K, Carli F, Aguilar-Nascimento JE de, Schäfer M, et al. Guidelines for perioperative care for pancreaticoduodenectomy: Enhanced Recovery After Surgery (ERAS®) Society recommendations. Clin Nutr 2012;31:817–30. https://doi.org/10.1016/j.clnu.2012.08.011.
70. Vonlanthen R, Lodge P, Barkun JS, Farges O, Rogiers X, Soreide K, et al. Toward a Consensus on Centralization in Surgery. Ann Surg 2018;268:712–24. https://doi.org/10.1097/SLA.0000000000002965.