Variation in use of open and laparoscopic distal pancreatectomy and associated outcome metrics in a universal health care system

Kjetil Søreide [a, b, *], Linn S. Nymo [c, d], Dyre Kleive [e, f], Frank Olsen [g], Kristoffer Lassen [d, e]

[a] Department of Gastrointestinal Surgery, Stavanger University Hospital, Stavanger, Norway
[b] Department of Clinical Medicine, University of Bergen, Bergen, Norway
[c] Department of Gastrointestinal Surgery, University Hospital of Northern Norway, Tromsø, Norway
[d] Institute of Clinical Medicine, the Arctic University of Norway, Tromsø, Norway
[e] Department of Hepatobiliary and Pancreatic surgery, Oslo University Hospital, Oslo, Norway
[f] Institute of Clinical Medicine, University of Oslo, Oslo, Norway
[g] Centre for Clinical Documentation and Evaluation (SKDE), Northern Norway Regional Health Authority, Tromsø, Norway

abstract

Background: Universal health care (UHC) should ensure equal access to and use of surgery, but few studies have explored variation in UHC systems. The objective was to describe practice of distal pancreatectomy in Norway covered exclusively by an UHC.

Methods: Data on all patients undergoing distal pancreatectomy from the Norwegian Patient Register over a 5-year period. Age- and gender-adjusted population-based resection rates (adj. per million/yr) for distal pancreatectomy were analysed across 4 regions and outcomes related to splenic salvage rate, hospital stay, reoperation, readmissions and 90-day mortality risk between regions. Risk is reported as odds ratio (OR) with 95% confidence interval (c.i.).

Results: Regional difference exist in terms of absolute numbers, with the majority of procedures done in one region (n ¼ 331; 59.7%). Regional variation persisted for age- and gender-adjusted population-rates, with highest rate at 23.8/million/yr and lowest rate at 13.5/mill/yr (for a 176% relative difference; or an absolute difference of þ10.3 resections/million/yr). Overall, a lapDP instead of an open DP was 3.5 times more likely in SouthEast compared to all other regions combined (lapDP rate: 83% vrs 24%, respectively; OR 15.4, 95% c.i. 10.1e23.5; P < 0.001). The splenic salvage rate was lower in SouthEast (19.9%) compared to all other regions (average 26.5%; highest in Central-region at 37.0%; P ¼ 0.010 for trend). Controlled for other factors in multivariate regression, 'region' of surgery remained significantly associated with laparoscopic access.

Conclusion: Despite a universal health care system, considerable variation exists in resection rates, use of laparoscopy and splenic salvage rates across regions.

Introduction

The use of common surgical procedures can vary considerably across regions [1]. Even within countries having universal health care (UHC) coverage and similar access to care, the regional variation in provision of certain procedures, use of certain techniques (e.g. minimal invasive surgery) or surgical care can vary consider- ably [2,3]. In Scandinavia, variation in both the use of laparoscopic access and surgical care for gastrointestinal disease has been demonstrated [2e4].

A laparoscopic approach is increasingly advocated for resection of lesions in the distal pancreas with studies pointing to favourable short-term outcomes [5]. However, in studies reporting nationwide data, use of laparoscopic resections vary from 12% as reported in France [6] to 59% in Norway [7]. However, regional variation may exist within a country based on both catchment area, surgical volumes, hospital and surgeon practices but has not been investigated in detail.

In general, variation in surgical practice is largely described as or, believed to be, a result of differences in illness burden (e.g. variation in disease incidence, prevalence or stage), variation in

* Corresponding author. Department of Gastrointestinal Surgery, P.O. Box 8100, N-4068, Stavanger, Stavanger University Hospital, Stavanger, Norway.
E-mail address: ksoreide@mac.com (K. Søreide).

diagnostic practices (e.g. threshold for use of imaging studies in the population) and variation in patients' attitudes towards intervention. However, data suggest that this can only explain a small degree of regional variation in surgery rates [1]. Evidence demonstrates that surgical variation results mainly from differ- ences in physician beliefs about the indications for surgery and the extent to which patient preferences are incorporated into treat- ment decisions. These two components of clinical decision-making help to explain the so-called ‘surgical signatures’ of specific pro- cedures, and why some consistently vary more than others.

We have previously shown that there was little variation in the population-based resections rates for pancreatoduodenectomy (Whipples procedure) across four health regions in Norway [8]. Notably, pancreatoduodenectomy is exclusively performed as open surgery in Norway and predominantly for malignant/premalignant conditions according to national guidelines. As a complex and high-risk procedure, the practice of pancreatoduodenectomy may be less prone to variation within a regulated system, compared to that of distal pancreatic resection. Variation in the practice of laparoscopic distal pancreatic resection is still evident with considerable differences in opinions, attitudes as well as experience in laparoscopy across the globe [9].

In Norway, the universal health care system allows for registration of all hospital-based procedures and hospital admissions that can be matched to a select number of valid and robust out- comes across all hospitals. In the ongoing process of adopting new techniques into routine practice in pancreatic surgery, an overall monitoring of procedural implementation and use across a health care system and their associated outcomes is highly warranted.

Thus, the aim of this study was to investigate the regional variation in use of distal pancreatectomy in a UHC system where fee-for-service and insurance coverage does not impact on surgical practice.

Material and methods

Study design

This was a longitudinal, observational national 5-year cohort study covering the universal health care system in Norway (from 1.1.2012 to 31.12.2016), as described in detail previously for nationwide data and time-trends [7,8,10] and consulting the guidelines for Strengthening the Reporting of Observational Studies in Epidemiology in Epidemiology (STROBE) [11].

Ethics

Centre of Clinical Documentation and Evaluation (SDKE, Northern Norway Regional Health Authority; Tromsø, Norway) holds a concession from the Norwegian Data Protection Authority to access data from the Norwegian Patient Registry (NPR). The Norwegian Data Inspectorate licensed the data registry at Centre for Clinical Documentation and Evaluation (ref. 15/00271e2/CGN and 16/00289e2/CGN). The study design is based on clinical administrative data and thus non-experimental in design. Further ethical approval or obtaining informed consent was not required according to Norwegian law for this study.

Data from the Norwegian Patient Registry (NPR)

The details of the inclusion and exclusion criteria have been presented previously [7,10]. Briefly, all Norwegian hospitals must submit data to the Norwegian Patient Registry (NPR) for registry and reimbursement purposes. The selected NPR variables have good data quality and high completeness [12]. A more detailed description of data capture and coding retrieval have been described previously [10], and reported for pan- creatoduodenectomy [8] and distal pancreatic resections [7] in a nationwide perspective. Operations were identified from the Nordic Medico-Statistical Committee (NOMESCO) Classification of Surgical Procedures (NCSP), version 2014 [13], with codes for open (JLC10) and laparoscopic (JLC11) distal pancreatectomy with or without inclusion of splenectomy code (open or laparoscopic; JMA10 or JMA11). Codes used for simple ‘laparoscopy’ or ‘explor- ative laparoscopy’, e.g. for staging procedures (JAH01 or JAH21) were not considered as a laparoscopic resection unless accompa- nied by a resectional code for laparoscopy. Thus, only the actual resectional codes (JLC10 and JLC11) where used to define the ‘open’ or ‘laparoscopic’ approach.

Norwegian health care system and regional autonomy

Norway has a universal health care program for all citizens that ensure equal access to care [14]. Each of the four regional health authorities (RHA; Fig. 1) governs the medical and surgical care through several health trusts in several counties and municipal- ities, with both several district hospitals and some university hos- pitals in each region. In Norway, all surgical resections for malignant or premalignant lesions within the abdomen are per- formed in public hospitals. Encrypted patient serial numbers make it possible to describe patient pathways involving all hospitals across health trusts and over several years. Only 5 hospitals per- formed HPB surgery across the 4 health regions during the study period (Fig. 1). Analyses are done for variations between each re- gion. As the SouthEast region represents the largest population (about half the patients in the cohort) and has had a long-standing interest in laparoscopic pancreatic surgery [15e17], analysis were also done for differences between the SouthEast region and the other regions combined.

Population-based resection rates

The population data for Norway and for each RHA catchment area (Fig. 1) are derived from Norway Statistics (www.ssb.no) at the time of study period. Adjusted resection rates for the population of each RHA was done based on population demographics available from Statistics Norway [18] and using the index year of 2015 for age- and gender-adjustments for the study period (Fig. 1). Population-based resection rates (per 1.000.000 inhabitants) were calculated for all distal resections and separately for open and laparoscopic procedures for the study period.

Patient identifier and registry data

All Norwegian citizens have a unique 11-digit personal identifier that allows tracking between hospitals, regions and registries, when given appropriate concession under data-protection regulations (e.g. such as the current concession held by NPR). Notably, hospital stay is possible to monitor after discharge across health trusts and other hospitals by coupling the unique patient identifier with any subsequent stay at any Norwegian hospital with an admission date within 30 days from the index procedure. Hospital stay was reported as described in detail previously [10] using as an aggregated length of stay (aLoS). An aLoS was counted as the total (cumulative) number of nights spent in any hospital within the first 30 days from an index operation; index stay, pluss any transfer or readmissions within the same 30-day period. In order to explore any differences in rates of a long (>1 week) or very long (>2 weeks) aLOS, groups were dichotomized and compared.

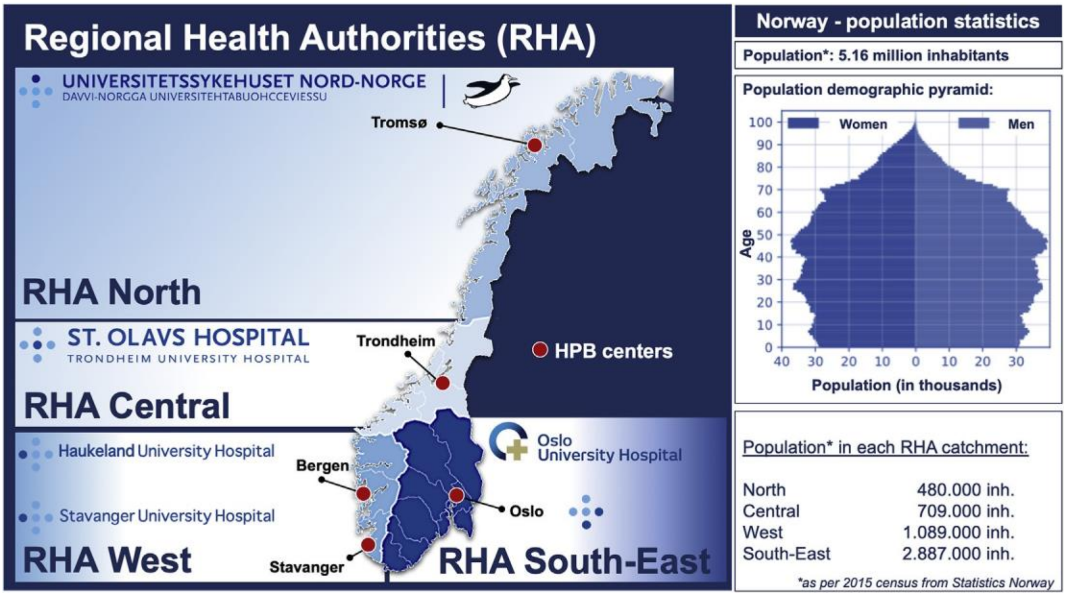

Fig. 1. Description of the regional health regions and catchment population.
Legend: There are 5 centres in Norway doing hepatobiliary and pancreatic (HPB) surgery during the study period across the regional health authorities (RHA): one in the North (University Hospital of Northern-Norway), one in Central (St. Olav's Hospital) Regional Health Authority region and two in the West (Haukeland University Hospital; and, Stavanger University Hospital) and one in SouthEast (Oslo University Hospital at Rikshospitalet). Population demographics are presented from Norway statistics (www.ssb.no); the population in urban regions are slightly younger than those in rural areas. The three urban regions with highest population density are Oslo, Bergen and Stavanger.

Definitions used

As described previously [7], grouping of patients into di- agnostics groups was done on a pragmatic basis. Thus, patients were designated to one of three disease groups, as used by others [19], reflecting the underlying disease or indication for surgery based on the coding provided from ICD-10 codes, as 'Malignant' (e.g. C25 codes), 'Premalignant/cysts' (e.g. D37 codes or K86.2) or 'Benign, other' (e.g. D13.6 or D13.7 codes), as described previously [7].

Surgical access was assigned based on the designated code for 'laparoscopic' or 'open' resection in the register. Notably, coding for converted cases does not exists and are thus not accounted for. The designated category assumes that the actual coding reflects the predominant part of the procedure, if converted (e.g. early con- version is likely to be coded as open; late conversions may have been coded as laparoscopic).

Splenic salvage is defined as any distal pancreatectomy done without concurrent splenectomy (i.e. without a code for open 'JMA10' or laparoscopic splenectomy 'JMA11') and reported as a rate for all procedures (e.g. % done without concomitant splenectomy) and separately for open and laparoscopic procedures.

Multivisceral resections were defined as any distal pancreatec- tomy (±splenectomy) that also included an additional resectional procedure, such as resection of stomach, colon, or adrenals/kidney. Comorbidity was described by the Charlson Comorbidity Index (CCI) [20] using the methods described by Quan et al. [21] for administrative data and Charlson Age-adjusted Comorbidity Index (CACI) for which each decade over 40 is given one added point to the CCI score [22]. A value for ≤CI 2 and CA≤I 6 were considered as 'high comorbidity' for the current study.

Assessment of outcomes between regions

For each RHA, the previously described short-term outcomes for evaluation included hospital stay (the accumulated days spent in hospital, including index hospital stay þ any transfer stay þ any readmissions: reported as 'aggregated length of stay', or aLOS) [7]. Furthermore, reoperations, readmissions and mortality at 90 days (90-d mortality) were compared.

Statistical analyses

Data were analysed using SAS 9.4 (SAS Institute, Cary NC) and Statistical Package for Social Sciences (IBM© SPSS© for Mac, v. 25). Descriptive analyses are presented as medians or as rates (%) and, where applicable, analysed by non-parametric tests for continuous variables or by Chi-square or Fischer's exact test for rates. Chi-square with four degrees of freedom was used to test for trend in variation between all the four RHAs and presented as P_{trend}. Analyses of between regions were further dichotomized into 'South-East' vrs 'all others'. Risk analyses was presented for regions dichotomized to South-East vs all others and presented as odds ratio (OR) with 95% confidence intervals (95% c.i.). Multivariable analysis was done using binominal regression (Forward Wald). All statistical tests were two-tailed and statistical significance set at $P < 0.050$.

Results

A total of 554 resections were included (Fig. 2), showing distribution of procedures between each RHA and the associated laparoscopy rate.

Regional case-mix

Patients' distribution of age, gender and comorbidity between regions are presented in Table 1 and Fig. 3. A significant difference in trend between age-groups was present between regions (P_{trend} 0.049; Fig. 3), related to differences in the middle aged (65–74 years) and oldest (>75 yrs) groups of patients. The differ- ence persisted when comparing SouthEast to all others, with a

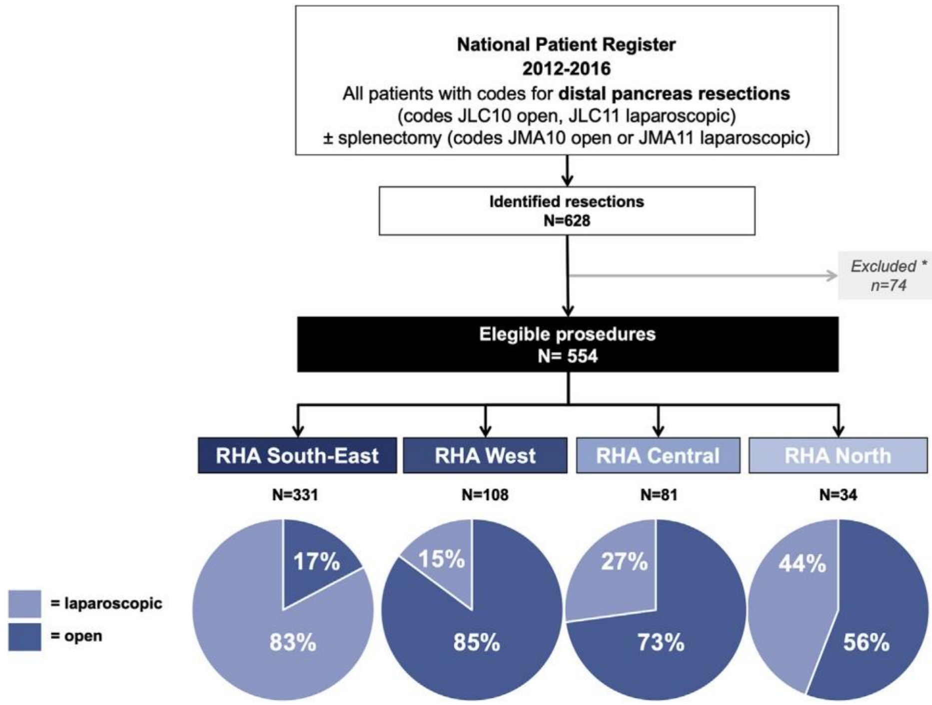

Fig. 2. Flowchart of study population and laparoscopic rate in each RHA
Legend:*Excluded were distal pancreatectomies not done as a primary pancreatic resection (e.g. as part of a resection for gastric cancer or a colonic splenic flexure cancer). Thus, any case with a pancreas resection code coupled with codes representing another disease (e.g. colon resection with diagnostic ICD-10 code of colon cancer, e.g. C18.x) were excluded. Codes of distal pancreas resection with a trauma diagnosis (S.x codes) were excluded. Cases with missing dates for hospital stay were also excluded.
P_{trend} <0.001 for differences in laparoscopy rate between the regions.

lower rate of elderly patients operated in the SouthEast (14% vs 22%; P ¼ 0.008). No difference in the number of patients with high comorbidity was found between regions when comparing all DPs. However, when stratified for laparoscopy as the procedure, there were significantly more men in the SouthEast (54% vs 38% in all other; OR 1.4, 95% c.i. 1.0e2.1; P ¼ 0.026), fewer elderly ≤ 75 years (15% in SouthEast vs 21% in all others; P ¼ 0.046), fewer patients with high comorbidity (SouthEast 9% vs 19% for all others; OR 2.3, 95% c.i. 1.0e5.2; P 0.036) and fewer patients had splenic salvage in SouthEast (21% vs 51% for all others; OR 1.6, 95% c.i. 1.2e2.1; P < 0.001) compared to all other regions. Such differences were not found for the open DP groups when comparing between dichotomized regions, except for a higher rate of CCI>2 in the open category for SouthEast compared to all others (30% vs 17%; OR 1.7, 95% c.i. 1.0e2.9; P ¼ 0.038).

Table 1
Distribution of patient characteristics between health regions.

	South East	West	Central	North	P_{trend}
N	*331*	*108*	*81*	*34*	
Women, n (%)	160 (48%)	67 (62%)	41 (51%)	16 (47%)	*0.093*
CCI					*0.943*
≥2, n (%)	57 (17.2%)	16 (14.8%)	13 (16.0%)	6 (17.6%)	
CACI					*0.340*
>6	238 (71.9%)	70 (64.8%)	52 (64.2%)	25 (73.5%)	
Diagnostic gr.					*0.740*
Malignant	193 (58.3%)	63 (58.3%)	48 (59.3%)	16 (47.1%)	
Premalignant	121 (36.3%)	38 (35.2%)	29 (35.8%)	14 (41.2%)	
Benign	17 (5.1%)	7 (6.5%)	4 (4.9%)	4 (11.8%)	

CCI denotes Charlson Comorbidity Index.
CACI denotes Charlson Age-Comorbidity Index.

Population-based resection rates and use of laparoscopy

There was a significant difference in laparoscopy rate between the four RHA with SouthEast (83%) standing out with a much higher rate than all other regions (lowest RHA West 15%), or an OR of 15.4 (95% c.i. 10.1e23.5; P < 0.001) when comparing to all other regions combined. Both the absolute number and the relative rate of laparoscopy varied considerably between the health regions (Fig. 4). Considerable regional difference across Norway were found in terms of absolute highest and lowest numbers (SouthEast ¼ 331, 59.7%) and North (n ¼ 34, 6.1%, respectively; a 10-fold difference). The population-adjusted resection rates for all distal pancreatectomies per RHA is presented in Fig. 4. The differences in overall, open and laparoscopic rates persisted when adjusted per population (23.8/million/yr vs 13.5/mill/yr; 176% relative difference) with an absolute difference of 10.3 resections/million/yr between the region with highest and lowest resection-rate. Overall, having a lapDP rather than an open DP was over 3.5 times more likely in SouthEast compared to all other regions (82.8% vs. 23.5% LDPs, respectively; OR 15.4, 95% c.i. 10.1e23.5; P < 0.001).

Regional variation in surgery and outcomes

Surgical variation in resection, including splenic salvage rate and multivisceral resections are presented in Table 2. The splenic salvage rate was slightly lower in SouthEast (19.9%) compared to the other regions (average 26.5%; highest in Central-region at 37.0%; Fig. 5). Overall, a laparoscopic approach was significantly associated with splenic-salvage (Fig. 5; OR 1.6, 95% c.i. 1.0e2.4; P ¼ 0.035). However, this remained only significant for the 'other regions' and not SouthEast, for an overall splenic salvage rate of 26.5% in the 'others regions'. The open salvage rate was 18.8% (32 of 170) and that of laparoscopic 50.9% (27 of 53) for an OR of 4.5 (95%

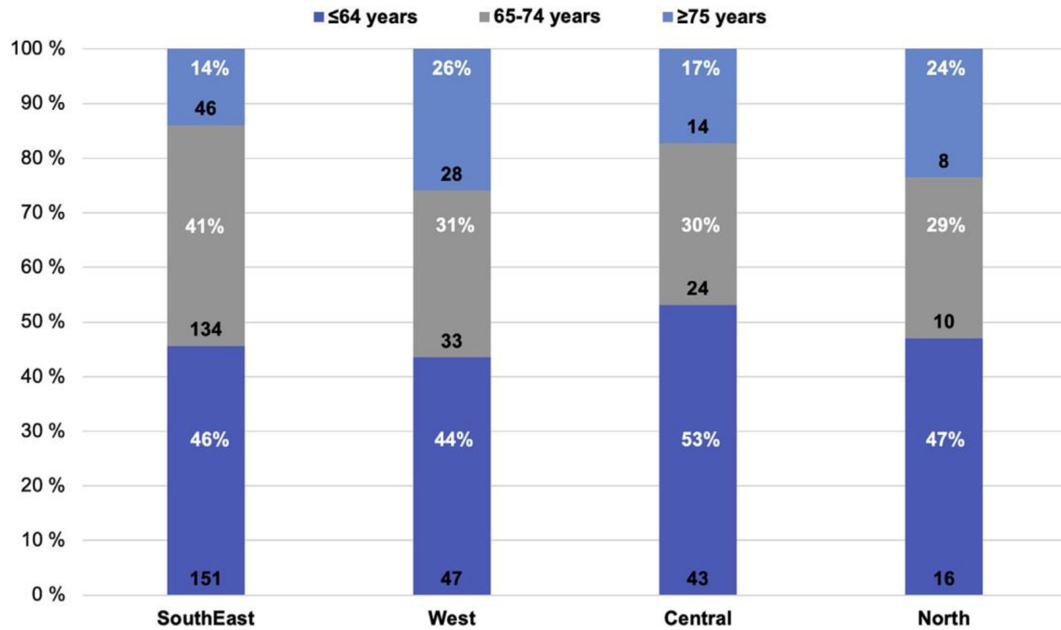

Fig. 3. Distribution of patients' age-groups between regions.
Black numbers represent the absolute number within each category (n), while white numbers are rates (%) within each category.

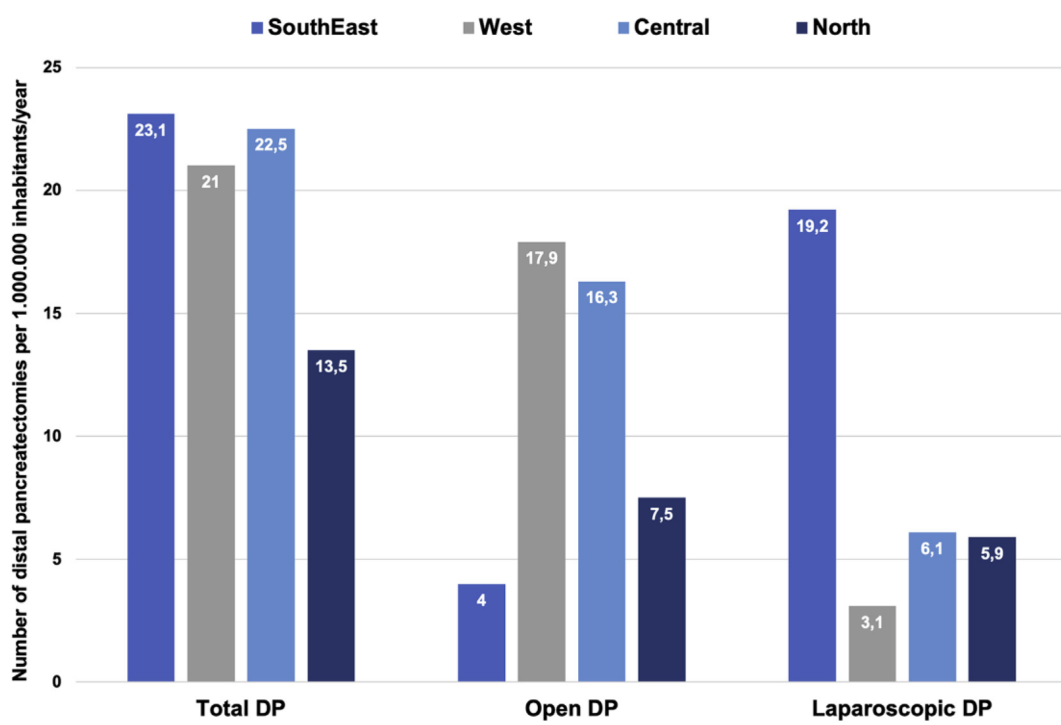

Fig. 4. Population-based resection rates of distal pancreatectomy.
Legend: Resection rates are age- and gender-adjusted over time and presented per 1000 000 inhabitants. A.) Total; B) open, C) laparoscopic.

ci 2.3e8.7; P < 0.001). No such association was found for age, gender, comorbidity, or diagnostic groups.

The difference between regions in aLOS >1 week (SouthEast 41% vs 57% for all others; OR 1.9, 95% c.i. 1.1e3.5; P ¼ 0.030) were only significant between regions for the laparoscopic DP group, but not for the open group. The difference in rates >2 weeks was only significant for all DPs compared between regions, but not for open or laparoscopy alone.

There were no regional differences in reoperations, readmissions and 90-day mortality between regions.

In multivariate regression, the factors related to use of lapDP when controlled for gender, age, year of procedure, comorbidity class, diagnostic groups, and region of surgery, only region remained significant predictor of having a laparoscopic approach, both when analysing between each of the 4 regions and when dichotomized to SouthEast vrs 'all others' (adjusted OR 15.4; 95% CI

Table 2
Distribution of distal pancreatectomy and related outcomes between regions.

	South East	West	Central	North	P_{trend}
N	*331*	*108*	*81*	*34*	
Spleen salvage, n (%)	66 (19.9%)	22 (20.4%)	30 (37.0%)	7 (20.6%)	*0.010*
Multivisceral	7 (2.1%)	4 (3.7%)	2 (2.5%)	3 (8.8%)	*0.152*
Reoperation, n (%)	17 (5.1%)	12 (11.1%)	2 (2.5%)	3 (8.8%)	*0.057*
Readmission, n (%)	67 (20.2%)	23 (21.3%)	13 (16.0%)	6 (17.6%)	*0.799*
Hospital stay >7 days, n (%)	155 (46.8%)	93 (86.1%)	59 (72.8%)	21 (61.8%)	*<0.001*
>14 days, n (%)	62 (18.7%)	38 (35.2%)	24 (29.6%)	10 (29.4%)	*0.003*
90d mortality	6 (1.8%)	2 (1.9%)	0	0	*0.546*

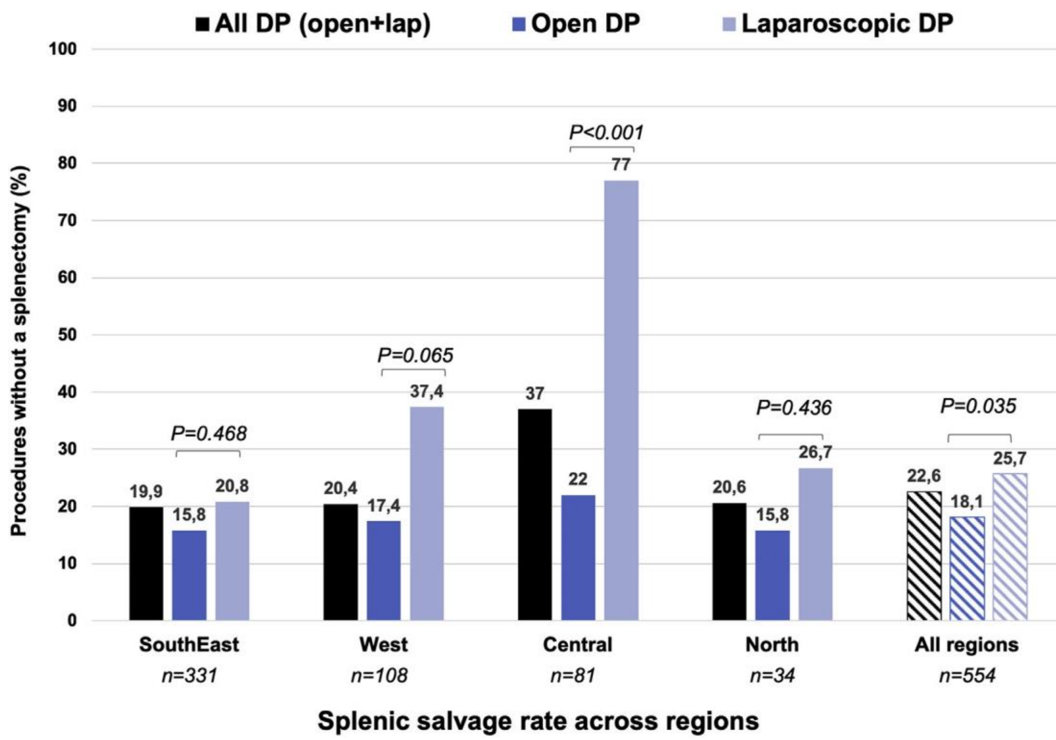

Fig. 5. Variation in splenic salvage rates between regions.

10.1e23.5; P < 0.001).

Keeping region as a dichotomized variable in multivariable analyses and adjusting for surgical access, reoperations were significantly associated with diagnostic groups (P < 0.048) but no other variables. No significant associations were found to readmissions, reoperations or 90-day mortality.

Discussion

The current study of practice of distal pancreatectomy in a UHC system found considerable variation across four health regions. Variation was evident for population-adjusted resection rates, to some extent for case-mix (including age-groups, gender and comorbidity in subgroups), for use of laparoscopic approach, for splenic salvage rate, and also for length of hospital stay. No differences between regions were found in other outcomes, including rates of reoperations, readmissions and 90-day mortality.

We have previously shown that use of distal pancreatectomy is increasing overall in Norway, and this is related to a significant increase in laparoscopic procedures [7]. One should keep in mind that while resection rates in Norway (during the same time period) also increased for pancreatoduodenectomies, the difference in population-adjusted resection rates between regions was negligible for this procedure [8]. Thus, rates of pancreatoduodenectomies stand in contrast to the current findings that demonstrate a 176% relative difference in the population-adjusted resection rate between the region with the lowest and the highest rates. In absolute numbers, an excess of 10 procedures per million per year is done in the SouthEast compared to the region with lowest resection rate (North). This difference is less prominent compared to the two other regions with a higher total number of procedures, the West (~2 excess procedures/mill/yr) and Central (~0.6 excess procedures/mill/yr) regions. The variation in numbers may represent statistical outliers and chance due to the low total numbers in some regions and for some years. However, one may not exclude the possibility for a volume-effect ("the more you do, the more you do") or a procedure selection bias (perceived less invasive procedure by laparoscopy, thus more likely to undertake the procedure), e.g. a parallel to the significant increase in cholecystectomies done in association with the introduction of laparoscopy [23e25], without a concomitant documented increase in the incidence of biliary disease.

Nonetheless, the difference in use of laparoscopic approach is considerable, with a skewed number of laparoscopic procedures done in SouthEast. The high use of laparoscopic approach is mirrored in the reduced overall use of hospital days, with lower average aLOS, and fewer patients who spend longer times in hospital (>1 week or >2 weeks). However, there was no improvement in splenic salvage rate, readmission rate nor in reoperation rates compared to the other regions. Mortality was not different between regions, with 90d mortality only reported in the two regions doing most procedures, the West and the SouthEast.

The higher resection rate in one region in Norway compared to the other regions in the same country, also when adjusted for age and gender distribution in the population, warrants further investigation. The administrative nature of the dataset allows for hypothesis-generating results, which needs to be corroborated with other and more detailed data. However, there seems to be some variation in case-mix noted between regions, with fewer elderly patients and more men chosen for laparoscopy in the SouthEast region. Furthermore, those who had open surgery in the same region had significantly higher comorbidity. The current dataset does not allow for investigation into explanatory factors such as histopathology, tumour size, patient obesity or previous surgery, any findings on pre-operative imaging and, particular outcomes from multidisciplinary discussions. One may perceive that a policy towards resection [26] rather than surveillance of smaller lesions, such as asymptomatic pancreatic neuroendocrine tumours, may contribute to the higher resection rates but this would need confirmation based on other granular data including histopathology confirmed diagnoses. However, it serves to be mentioned that it is generally believed that the vast majority of asymptomatic, small suspected neuroendocrine lesions may best be served with surveillance [27], as only a minority will ultimately need resection [26,27]. However, detailed comparison of lesion pathology would be needed to substantiate these assumptions in the current cohort.

The rate of procedures done without a splenectomy was significantly higher in the laparoscopic DPs, but much lower than the salvage rate reported by others at 41e52% [28,29]. We have no information on the intended or unplanned splenectomy in conjunct with distal pancreatectomy in the current series. As the salvage rate is based on splenectomy being coded or not, the data may be not be accurate. However, as splenectomy is actively coded, the data presented most likely represents a minimum set of splenectomies done, and the splenic salvage rate may indeed be lower if codes are missing. However, we believe the findings to represent actual variation in practice between regions and the current attitude towards splenic salvage between regions. This warrants further in-depth investigation into reasons for variation in practice. Of note, SouthEast region has had a liberal approach to laparoscopic resection for body and tail adenocarcinoma, constituting 25% of all lapDP done in the period 2001e2016 [30] and these are usually done with splenectomy as part of the procedure. As laparoscopic DP is somewhat controversial for pancreatic adenocarcinoma and many are still awaiting the oncological outcomes from randomized studies, it may further reflect a clear difference in attitude towards resection which has not been followed in the other health regions. From a short-term perspective evaluating cost-benefit, quality of life and cosmesis, open and laparoscopic approach are comparable in the outcomes [31]. For oncological outcomes in distal resections with either open or laparoscopic access, only surrogate endpoints are reported so far [32].

Variations in other medical fields may also contribute to variation in resections in the population. In theory, variation in the use of CTand MRI may lead to more incidental findings, which again may lead to more referrals and hence surgeries being done. Previous data from Norway have reported a considerable variation (60% variation) in use of imaging studies between the urban capitol of Oslo (in the SouthEast) and the more rural district in county Finnmark (in the North) [33]. The difference has recently been corroborated when investigated for musculoskeletal imaging studies [34] and in an audit from the Office of the Auditor General, finding a more than 3-fold difference in population-adjusted use of CT and MRI use across health trusts [35]. Thus, a higher than expected use of cross-sectional imaging in the SouthEast may translate into a higher number of incidental lesions, leading off to a higher number of resections per population. Of notice, others have associated high-density regions of imaging to a higher use of surgery, such as found for nephrectomy in the US [36]. Notably, these hypotheses remain speculative for the current study, but warrants further investigation to gain better insight into mechanisms lead- ing to variation in care.

Limitations

Some limitations to use of administrative data should be mentioned. For one, the diagnostic categories used in this cohort is not accurate and may thus not be used to compare studies who present diagnosis as obtained by final histopathology. Notably, these codes and the diagnostic groups only reflect the working hypothesis under which patients may have been admitted, worked up, operated on and later discharged and may for some patients change on final pathology reports. However, for the purpose of this study, the grouping suffices to explain the surgical intent and use of surgery per se and surgical access modality to treat lesions in the tail of the pancreas. More importantly, the dataset lacks granular data on the specific procedures and the outcomes as well as causes for longer stay, readmissions or reoperations. These variables need to be obtained from sources of quality assurance and crosschecks with actual electronic patient records, and we intend to go forward with this by using data from the recently established national quality register for gastrointestinal surgery [37].

Norway has a population of roughly 5.4 million which is comparable to other countries or states such as Denmark, Scotland, Ireland or the states of Minnesota or Colorado in the US. Notably, huge geographical variation in terms of access and travel distances exists between the same countries, preventing immediate comparison for hospital catchment areas. However, we believe the findings may have generalizable and transferable interest to other regions with comparable systems and population sizes, albeit accepting both that differences in geography and health care provision may exist.

Thus, the findings reported herein are associations and not causations e they are hypothesis-generating data that warrant research effort into a better understanding of the reported variation across the four regions in Norway. As a similar variation was not noted for the same regions and hospitals for pancreatoduodenectomies [8], we assume that the variation lies in the practice of distal pancreatectomy and likely as an effect of minimal invasive access that may influence choice to operate over observation for some indications. This should be kept in mind when comparing results and outcomes from single-center studies. However, assumptions must be confirmed by data with in-depth quality in order to explore causations.

Disclaimer

Data from the Norwegian Patient Register has been used in this publication. The interpretation and reporting of these data are the sole responsibility of the authors, and no endorsement by the Norwegian Patient Register is intended nor should be inferred.

Author disclosures

Kjetil Søreide has no conflicts of interest or financial ties to disclose.

Linn S. Nymo has no conflicts of interest or financial ties to disclose.

Dyre Kleive has no conflicts of interest or financial ties to disclose.

Frank Olsen has no conflicts of interest or financial ties to disclose.

Kristoffer Lassen has no conflicts of interest or financial ties to disclose.

Author contributions

Conception or design of the work: KS.

Acquisition, analysis, or interpretation of data for the work: KS, LSN, DK, FO, KL.

Drafting the work: KS.

Revising it critically for important intellectual content: KS, LSN, DK, FO, KL.

Final approval of the version to be published: KS, LSN, DK, FO, KL.

Agreement to be accountable for all aspects of the work: KS, LSN, DK, FO, KL.

Funding

None.

References

[1] Birkmeyer JD, Reames BN, McCulloch P, Carr AJ, Campbell WB, Wennberg JE. Understanding of regional variation in the use of surgery. Lancet (London, England) 2013;382:1121e9.

[2] Sundbom M, Hedberg J. Use of laparoscopy in gastrointestinal surgery in Sweden 1998-2014: a nationwide study. Scand J Surg : SJS : official organ for the Finnish Surgical Society and the Scandinavian Surgical Society 2017;106:34e9.

[3] Wennervaldt K, Kejs AM, Lipczak H, Bartels P, Borre M, Fristrup CW, et al. Regional variation in surgery for pancreatic cancer in Denmark 2011-2015. Dan Med J 2018;65:A5503.

[4] Stormark K, Søreide K, Søreide JA, Kvaløy JT, Pfeffer F, Eriksen MT, et al. Nationwide implementation of laparoscopic surgery for colon cancer: short-term outcomes and long-term survival in a population-based cohort. Surg Endosc 2016;30:4853e64.

[5] Rosok BI, de Rooij T, van Hilst J, Diener MK, Allen PJ, Vollmer CM, et al. Minimally invasive distal pancreatectomy. HPB : the official journal of the International Hepato Pancreato Biliary Association 2017;19:205e14.

[6] Sulpice L, Farges O, Goutte N, Bendersky N, Dokmak S, Sauvanet A, et al. Laparoscopic distal pancreatectomy for pancreatic ductal adenocarcinoma: time for a randomized controlled trial? Results of an all-inclusive national observational study. Ann Surg 2015;262:868e73. discussion 873-864.

[7] Søreide K, Olsen F, Nymo LS, Kleive D, Lassen K. A nationwide cohort study of resection rates and short-term outcomes in open and laparoscopic distal pancreatectomy. HPB : the official journal of the International Hepato Pancreato Biliary Association 2019;21:669e78.

[8] Nymo LS, Søreide K, Kleive D, Olsen F, Lassen K. The effect of centralization on short term outcomes of pancreatoduodenectomy in a universal health care system. HPB : the official journal of the International Hepato Pancreato Biliary Association 2019;21:319e27.

[9] van Hilst J, de Rooij T, Abu Hilal M, Asbun HJ, Barkun J, Boggi U, et al. Worldwide survey on opinions and use of minimally invasive pancreatic resection. HPB : the official journal of the International Hepato Pancreato Biliary Association 2017;19:190e204.

[10] Lassen K, Nymo LS, Olsen F, Søreide K. Benchmarking of aggregated length of stay after open and laparoscopic surgery for cancers of the digestive system. BJS open 2018;2:246e53.

[11] von Elm E, Altman DG, Egger M, Pocock SJ, Gotzsche PC, Vandenbroucke JP. Strengthening the reporting of observational studies in epidemiology (strobe) statement: guidelines for reporting observational studies. BMJ (Clinical research ed) 2007;335:806e8.

[12] Mangerud W, Kjelvik M, Krokan T. Activity data for somatic health care in the specialist health service 2016. Oslo: Helsedirektoratet; 2017. Norwegian patient registry [in norwegian].

[13] Nomesco classification of surgical procedures. In: Care NCfCiH, editor. Nordic centre for classifications in health care; 2010.

[14] Soreide K, Glomsaker T, Soreide JA. Surgery in Norway: beyond the scalpel in the 21st century. Arch Surg 2008;143:1011e6. Chicago, Ill : 1960.

[15] Røsok BI, Marangos IP, Kazaryan AM, Rosseland AR, Buanes T, Mathisen O, et al. Single-centre experience of laparoscopic pancreatic surgery. Br J Surg 2010;97:902e9.

[16] Edwin B, Mala T, Mathisen O, Gladhaug I, Buanes T, Lunde OC, et al. Laparoscopic resection of the pancreas: a feasibility study of the short-term outcome. Surg Endosc 2004;18:407e11.

[17] Sahakyan MA, Kim SC, Kleive D, Kazaryan AM, Song KB, Ignjatovic D, et al. Laparoscopic distal pancreatectomy for pancreatic ductal adenocarcinoma: long-term oncologic outcomes after standard resection. Surgery 2017;162:802e11.

[18] StatisticsNorway. Key figures for the population - statistics Norway. Statistics Norway; 2018.

[19] Dokmak S, Fteriche FS, Aussilhou B, Levy P, Ruszniewski P, Cros J, et al. The largest european single-center experience: 300 laparoscopic pancreatic resections. J Am Coll Surg 2017;225:226e34. e222.

[20] Charlson ME, Pompei P, Ales KL, MacKenzie CR. A new method of classifying prognostic comorbidity in longitudinal studies: development and validation. J Chronic Dis 1987;40:373e83.

[21] Quan H, Sundararajan V, Halfon P, Fong A, Burnand B, Luthi JC, et al. Coding algorithms for defining comorbidities in icd-9-cm and icd-10 administrative data. Med Care 2005;43:1130e9.

[22] Charlson M, Szatrowski TP, Peterson J, Gold J. Validation of a combined comorbidity index. J Clin Epidemiol 1994;47:1245e51.

[23] Mallon P, White J, McMenamin M, Das N, Hughes D, Gilliland R. Increased cholecystectomy rate in the laparoscopic era: a study of the potential causative factors. Surg Endosc 2006;20:883e6.

[24] Ainsworth AP, Adamsen S, Rosenberg J. Cholecystectomy in Denmark 1989-2003. Ugeskr Laeg 2005;167:2648e50.

[25] Bakken IJ, Skjeldestad FE, Mjaland O, Johnson E. Cholecystectomy in Norway 1990-2002. Tidsskrift for den Norske laegeforening : tidsskrift for praktisk medicin. ny raekke 2004;124:2376e8.

[26] Sallinen VJ, Le Large TYS, Tieftrunk E, Galeev S, Kovalenko Z, Haugvik SP, et al. Prognosis of sporadic resected small (</¼2 cm) nonfunctional pancreatic neuroendocrine tumors - a multi-institutional study. HPB : the official journal of the International Hepato Pancreato Biliary Association 2018;20:251e9.

[27] Partelli S, Cirocchi R, Crippa S, Cardinali L, Fendrich V, Bartsch DK, et al. Systematic review of active surveillance versus surgical management of asymptomatic small non-functioning pancreatic neuroendocrine neoplasms. Br J Surg 2017;104:34e41.

[28] Dai MH, Shi N, Xing C, Liao Q, Zhang TP, Chen G, et al. Splenic preservation in laparoscopic distal pancreatectomy. Br J Surg 2017;104:452e62.

[29] Malleo G, Damoli I, Marchegiani G, Esposito A, Marchese T, Salvia R, et al. Laparoscopic distal pancreatectomy: analysis of trends in surgical techniques, patient selection, and outcomes. Surg Endosc 2015;29:1952e62.

[30] Sahakyan MA, Kleive D, Kazaryan AM, Aghayan DL, Ignjatovic D, Labori KJ, et al. Extended laparoscopic distal pancreatectomy for adenocarcinoma in the body and tail of the pancreas: a single-center experience. Langenbeck's Arch Surg 2018;403:941e8.

[31] van Hilst J, Strating EA, de Rooij T, Daams F, Festen S, Groot Koerkamp B, et al. Costs and quality of life in a randomized trial comparing minimally invasive and open distal pancreatectomy (leopard trial). Br J Surg 2019;106:910e21.

[32] van Hilst J, de Rooij T, Klompmaker S, Rawashdeh M, Aleotti F, Al-Sarireh B, et al. Minimally invasive versus open distal pancreatectomy for ductal adenocarcinoma (diploma): a pan-european propensity score matched study. Ann Surg 2019;269:10e7.

[33] Lysdahl KB, Borretzen I. Geographical variation in radiological services: a nationwide survey. BMC Health Serv Res 2007;7:21.

[34] Gransjoen AM, Lysdahl KB, Hofmann BM. Geographical variations in the use of diagnostic imaging of musculoskeletal diseases in Norway. Acta Radiol 2018 Nov 11. https://doi.org/10.1177/0284185118812204. 284185118812204. In press.

[35] Riksrevisjonen. Riksrevisjonens undersøkelse av bruken av poliklinisk bildediagnostikk [outpatient use of imagingdiagnostics]. Riksrevisjonens administrative rapport nr. 1 2017. Riksrevisjonen; 2017. p. 1e113. Riksrevisjonen (ed), https://www.riksrevisjonen.no/rapporter/Documents/2016-2017/Bildediagnostikk.pdf.

[36] Welch HG, Skinner JS, Schroeck FR, Zhou W, Black WC. Regional variation of computed tomographic imaging in the United States and the risk of nephrectomy. JAMA internal medicine 2018;178:221e7.

[37] Lassen K, Nymo LS, Kørner H, Thon K, Grindstein T, Wasmuth HH, et al. The new national registry for gastrointestinal surgery in Norway: Norgast. Scand J Surg : SJS : official organ for the Finnish Surgical Society and the Scandinavian Surgical Society 2018;107:201e7.