

Quality-of-care initiative in patients treated surgically for perforated peptic ulcer

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Background: Mortality and morbidity are considerable after treatment for perforated peptic ulcer (PPU). Since 2003, a Danish nationwide quality-of-care (QOC) improvement initiative has focused on reducing preoperative delay, and improving perioperative monitoring and care for patients with PPU. The present study reports the results of this initiative.

Methods: This was a nationwide cohort study based on prospectively collected data, involving all hospitals caring for patients with PPU in Denmark. Details of patients treated surgically for PPU between September 2004 and August 2011 were reported to the Danish Clinical Register of Emergency Surgery. Changes in baseline patient characteristics and in seven QOC indicators are presented, including relative risks (RRs) for achievement of the indicators.

Results: The study included 2989 patients. An increasing number fulfilled the following four QOC indicators in 2010–2011 compared with the first 2 years of monitoring: preoperative delay no more than 6 h (59.0 *versus* 54.0 per cent; $P = 0.030$), daily monitoring of bodyweight (48.0 *versus* 29.0 per cent; $P < 0.001$), daily monitoring of fluid balance (79.0 *versus* 74.0 per cent; $P = 0.010$) and daily monitoring of vital signs (80.0 *versus* 68.0 per cent; $P < 0.001$). A lower proportion of patients had discontinuation of routine prophylactic antibiotics (82.0 *versus* 90.0 per cent; $P < 0.001$). Adjusted 30-day mortality decreased non-significantly from 2005–2006 to 2010–2011 (adjusted RR 0.87, 95 per cent confidence interval 0.76 to 1.00), whereas the rate of reoperative surgery remained unchanged (adjusted RR 0.98, 0.78 to 1.23).

Conclusion: This nationwide quality improvement initiative was associated with reduced preoperative delay and improved perioperative monitoring in patients with PPU. A non-significant improvement was seen in 30-day mortality.

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Introduction

The incidence of peptic ulcer disease has been decreasing for several years¹. However, at the same time, the rate of emergency surgery for perforated peptic ulcer (PPU) has remained unchanged². Despite advances in diagnosis and intensive care treatment and monitoring, and

less invasive surgical techniques, mortality and morbidity following surgery for PPU remains considerable^{3,4}. In population-based studies of unselected patients, 30-day mortality rates of 25–30 per cent have been reported^{5–9}. An increasing prevalence of adverse prognostic factors, including older age, high American Society of Anesthesiologists (ASA) fitness score, co-morbidity, use

of non-steroidal anti-inflammatory drugs (NSAIDs) or steroids, and long preoperative delays leading to shock and organ failure, may contribute to the persistently high mortality rate in patients with PPU¹⁰.

In 2003, the Danish healthcare authorities initiated continuous monitoring of the quality of care (QOC) provided by all Danish public hospitals to patients with PPU via the Danish Clinical Register of Emergency Surgery (DCRES)¹¹. The aim of the present study was to analyse the database with respect to the results of this nationwide quality improvement initiative, including changes over time in baseline characteristics, QOC indicators and outcome measures.

Methods

This nationwide registry-based cohort study was approved by the Danish Data Protection Agency, and did not require informed patient consent according to Danish law. The manuscript was prepared in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement¹². All Danish hospitals treating patients with PPU were included.

Organization of the Danish Clinical Register of Emergency Surgery

Reporting to the DCRES is mandatory for all Danish hospitals, and all patients treated surgically for PPU in Denmark are registered prospectively. In total, 35 Danish hospital departments contributed to the database when data registration became nationwide in 2004. The database includes baseline characteristics, as well as perioperative clinical data.

A multidisciplinary group of healthcare specialists in the field of PPU, a board, a secretariat and a data management

group constitute the DCRES indicator group. The group meets one to three times annually to evaluate the QOC indicators (see below). Each year structured audit processes are performed nationally, regionally in the five Danish administrative regions, and locally in the hospital departments reporting to the database. Thereby, the clinicians, the heads of the departments, the hospital management, the regions and the public receive continuous feedback on the treatment of PPU. The results are made public once a year (<http://www.sundhed.dk>).

Study population

The cohort included all patients treated surgically for gastric or duodenal PPU in hospitals in Denmark between 1 September 2004 and 31 August 2011. Patients who received non-operative treatment and those with a malignant ulcer are not registered in the database.

Data extraction and management

The primary data record is uploaded by the surgeon using a standard case report form. Data are subsequently validated and transferred to an electronic database by the local DCRES representative at each site. The exact date of death is ascertained through linkage of the patient's civil registration number with the Danish Civil Registry System, which stores information on citizen vital statistics, including the exact date of death¹³.

Quality-of-care initiative and indicators

The aim of the DCRES is to improve nationwide PPU outcome through continuous public monitoring of clinically relevant perioperative indicators of PPU disease. Based on a systematic review of the literature on PPU¹⁴,

Table 1 Quality-of-care initiative

Quality indicator	Type of indicator	Definition	Quality-of-care standard (%) [*]
Preoperative delay	Process of care	≤ 6 h delay from hospital admission to surgery (out-of-hospital perforation) or from decision to operate to surgery (in-hospital perforation)	≥ 75
Prophylactic antibiotics	Process of care	Routine prophylactic antibiotics discontinued within 3 days after surgery	≥ 95
Bodyweight	Process of care	Daily weight measurement on days 1–3 after surgery	≥ 90
Fluid balance	Process of care	Daily use of fluid balance chart on days 1–3 after surgery	≥ 90
Vital signs	Process of care	Measurement and registration of vital signs (blood pressure, heart rate, temperature, pulse oximetry, level of consciousness) twice daily, on days 1–3 after surgery	≥ 90
Reoperative surgery	Clinical outcome	Any unplanned surgical procedure related to the primary operation (e.g. relaparotomy, relaparoscopy, drainage of abscess)	≤ 10
30-day mortality	Clinical outcome	Death within 30 days of primary surgical procedure	≤ 20

^{*}Based on scientific evidence, good clinical practice and good clinical results.

Table 2 Baseline, clinical and prognostic characteristics in 2989 patients with peptic ulcer perforation in Denmark from 2005 to 2011

	2005	2006	2007	2008	2009	2010	2011	Total
No. of patients	488	471	423	431	380	417	379	2989
Age (years)*	71 (58–81)	70 (58–82)	72 (58–81)	71 (59–79)	71 (60–81)	72 (61–82)	70 (60–80)	71 (59–81)
Women	277 (56.8)	249 (52.9)	234 (55.3)	230 (53.4)	206 (54.2)	260 (62.4)	203 (53.6)	1659 (55.5)
Body mass index (kg/m ²)*	23 (20–26)	23 (21–26)	23 (20–25)	23 (21–26)	23 (21–27)	23 (20–27)	23 (21–26)	23 (21–26)
In-hospital perforation	—	—	100 (23.6)	101 (23.4)	101 (26.7)	137 (32.9)	105 (27.7)	544 (26.8)
Shock on admission†	29 (5.9)	33 (7.0)	113 (26.7)	109 (25.3)	84 (22.1)	91 (21.8)	84 (22.2)	543 (18.2)
Haemoglobin (mmol/l)*	8 (7–9)	8 (7–9)	8 (7–9)	8 (7–9)	8 (7–9)	8 (7–9)	8 (7–9)	8 (7–9)
Creatinine (µmol/l)*	91 (71–131)	90 (69–133)	87 (68–130)	87 (65–125)	88 (66–135)	83 (63–117)	87 (66–134)	88 (68–132)
Aspirin	140 (28.9)	124 (26.3)	108 (25.5)	112 (26.0)	103 (27.1)	115 (27.6)	95 (25.1)	797 (26.7)
NSAIDs	195 (40.0)	174 (36.9)	155 (36.6)	146 (33.9)	115 (30.3)	124 (29.7)	129 (34.0)	1038 (34.7)
Steroids	58 (11.9)	59 (12.5)	48 (11.3)	45 (10.4)	32 (8.4)	33 (7.9)	31 (8.2)	306 (10.2)
SSRIs	—	—	38 (9.0)	38 (8.8)	35 (9.2)	35 (8.4)	35 (9.2)	181 (8.9)
Anticoagulants	18 (3.7)	23 (4.9)	30 (7.1)	25 (5.8)	23 (6.1)	31 (7.4)	32 (8.4)	182 (6.1)
Alcohol abuse‡	72 (14.8)	85 (18.0)	63 (14.9)	73 (16.9)	71 (18.7)	65 (15.6)	69 (18.2)	498 (16.7)
Daily tobacco use	232 (47.5)	226 (48.0)	214 (50.6)	236 (54.8)	199 (52.4)	198 (47.5)	181 (47.8)	1486 (49.7)
ASA fitness score								
I	108 (22.1)	93 (19.7)	95 (22.5)	100 (23.2)	56 (14.7)	74 (17.7)	71 (18.7)	597 (20.0)
II	158 (32.4)	138 (29.3)	142 (33.6)	148 (34.3)	137 (36.1)	137 (32.9)	103 (27.2)	963 (32.2)
III	152 (31.1)	157 (33.3)	127 (30.0)	116 (26.9)	136 (35.8)	150 (36.0)	147 (38.8)	985 (33.0)
IV	48 (9.8)	67 (14.2)	52 (12.3)	48 (11.1)	47 (12.4)	52 (12.5)	52 (13.7)	366 (12.2)
IV	6 (1.2)	5 (1.1)	4 (0.9)	8 (1.9)	3 (0.8)	3 (0.7)	5 (1.3)	34 (1.1)
≥ 1 coexisting disease§	314 (64.3)	320 (67.9)	281 (66.4)	289 (67.1)	280 (73.7)	291 (69.8)	279 (73.6)	2054 (68.7)
Gastric ulcer¶	221 (45.3)	223 (47.3)	202 (47.8)	212 (49.2)	190 (50.0)	226 (54.2)	215 (56.7)	1489 (49.8)

Values in parentheses are percentages unless indicated otherwise; *values are median (interquartile range). †Blood pressure less than 100 mmHg and heart rate more than 100 beats/min; the way of registering presence of shock changed in 2007. ‡Over 36 g alcohol/day for men and over 24 g/day for women. §One or more of the following: diabetes, chronic obstructive pulmonary disease, heart disease, liver cirrhosis, active cancer disease, acquired immune deficiency syndrome, or any other medically treated chronic disease. ¶As opposed to duodenal ulcer. NSAID, non-steroidal anti-inflammatory drug; SSRI, selective serotonin reuptake inhibitor; ASA, American Society of Anesthesiologists.

on national clinical guidelines for the perioperative care and treatment of PPU, and on considerations regarding the feasibility of collecting the required data in a routine clinical setting, the DCRES group decided to monitor the QOC by means of seven quality indicators. There were five process-of-care indicators: preoperative delay less than 6 h, discontinuation of prophylactic antibiotics, daily monitoring of bodyweight, daily monitoring of fluid balance and daily monitoring of vital signs; and two clinical outcome indicators: need for reoperative surgery and 30-day mortality¹⁵. The DCRES group assigned quality standards to the seven indicators, based on scientific evidence, good clinical practice and good clinical results (Table 1).

Patient characteristics

The following baseline and clinical data were registered: age; sex; body mass index (BMI); in-hospital *versus* out-of-hospital perforation; presence of shock (systolic blood pressure less than 100 mmHg and heart rate exceeding 100 beats/min); coexisting diseases; haemoglobin and creatinine levels on admission; use of aspirin,

NSAIDs, selective serotonin reuptake inhibitors (SSRIs), steroids and anticoagulants; alcohol abuse; daily use of tobacco; ASA fitness score; and ulcer site. In-hospital perforation *versus* out-of-hospital perforation, use of SSRI and need for reoperative surgery were included in the database in 2007.

Statistical analysis

Baseline and clinical characteristics are presented as distribution frequencies among all patients with PPU in Denmark within seven time intervals. These were defined as 12-month intervals starting on 1 September 2004. Testing for time trends was done using the χ^2 test or Cochran–Armitage test. The proportion of patients (with 95 per cent confidence interval, c.i.) who fulfilled the seven QOC indicators by study year and for each monitored hospital was calculated. The variation in QOC indicator results between hospitals is displayed graphically. To assess changes over time, the first 2 years of monitoring were compared with the most recent 2 years, using a log-binomial regression model to calculate crude relative risks (RRs) with 95 per cent c.i.¹⁶. Two-year intervals

instead of first *versus* last monitored year were chosen in order to improve statistical precision. For the two clinical outcome indicators, there was adjustment for the following prognostic co-variables: age, sex, BMI, comorbidity, tobacco smoking, alcohol abuse, and use of oral corticosteroids, anticoagulants, aspirin, NSAIDs and SSRIs.

The prevalence and pattern of missing values in the patient cohort were evaluated, and the data were found not to be missing completely at random. Consequently, multiple imputations ($n = 25$) for the missing values were used^{17,18}. The multivariable log-binomial regression model was used to calculate adjusted RRs within each imputed data set and estimates were pooled to get the overall estimation result. The regression model on the imputed data set was validated using goodness-of-fit tests and model diagnostics, and showed no indication of lack of fit.

Two-sided $P < 0.050$ was considered statistically significant. Data were analysed using the statistical software SAS[®] version 9.2 (SAS Institute, Cary, North Carolina, USA) and multiple imputations were performed in Stata[®] version 11.2 (StataCorp LP, College Station, Texas, USA) using *ice*¹⁹.

Results

A total of 2989 patients with PPU were registered in the database. Baseline, clinical and prognostic characteristics of the study population are shown in *Table 2*. Median (interquartile range) age was 71 (59–81) years; 55.5 per cent of the patients were women (1659 of 2989) and 68.7 per cent (2054 of 2989) had at least one of six different co-morbidities. Coexisting use of ulcerogenic drugs decreased in general throughout the study. The proportion of patients with coexisting heart disease, diabetes and the category ‘other chronic disease’ increased significantly from the first to last observation period ($P = 0.040$, $P = 0.003$ and $P < 0.001$ respectively) (*Fig. 1*). Correspondingly, the proportion of patients with at least one coexisting disease increased from 64.3 per cent (314 of 488) in 2005 to 73.6 per cent (279 of 379) in 2011 ($P = 0.002$), and the proportion of patients with ASA grade III increased from 31.1 to 38.8 per cent ($P = 0.020$) (*Table 2*). Finally, there was a shift in ulcer location from 45.3 per cent gastric ulcers in 2005 to 56.7 per cent in 2011 ($P < 0.001$).

The percentage of patients fulfilling the five process indicators from 2005 to 2011 is shown in *Fig. 2*. An increasing proportion fulfilled the indicator ‘preoperative delay at most 6 h’, from 54.0 per cent in 2005–2006

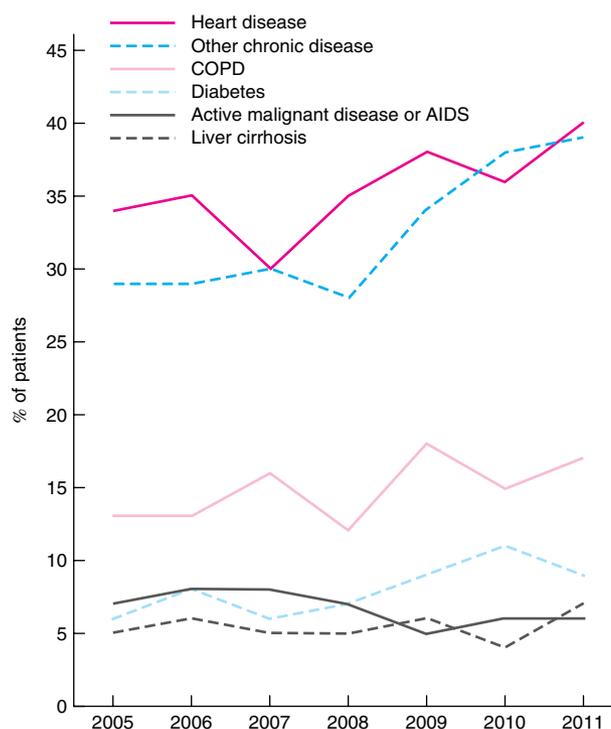


Fig. 1 Coexisting diseases in 2989 patients who had surgery for perforated peptic ulcer from 2005 to 2011. COPD, chronic obstructive pulmonary disease; AIDS, acquired immune deficiency syndrome

to 59.0 per cent in 2010–2011 ($P = 0.030$; RR 1.10, 95 per cent c.i. 1.01 to 1.19) (*Table 3*). However, these results were still far from the QOC standard set at 75 per cent. The proportion reaching the second indicator ‘discontinuation of prophylactic antibiotics’ decreased from 90.0 per cent in 2005–2006 to 82.0 per cent in 2010–2011 ($P < 0.001$; RR 0.92, 0.88 to 0.97), and did not reach the QOC standard of at least 95 per cent at any point. Daily monitoring of bodyweight improved from 29.0 per cent in 2007–2008 to 48.0 per cent in 2010–2011 ($P < 0.001$; RR 1.63, 1.43 to 1.86). Daily monitoring of fluid balance improved from 74.0 per cent in 2007–2008 to 79.0 per cent ($P = 0.010$; RR 1.07, 1.02 to 1.13), and daily monitoring of vital signs from 68.0 to 80.0 per cent ($P < 0.001$; RR 1.17, 1.10 to 1.24).

As regards the clinical outcome indicators, the rate of reoperative surgery did not change substantially over time (adjusted RR 0.98, 0.78 to 1.23), and was above the QOC standard of maximum 10 per cent in all years (*Fig. 3a*, *Table 4*). The 30-day mortality rate reached 25–30 per cent in most years. The median 30-day mortality rate in the entire cohort was 26.7 (95 per cent c.i. 25.1 to 28.3)

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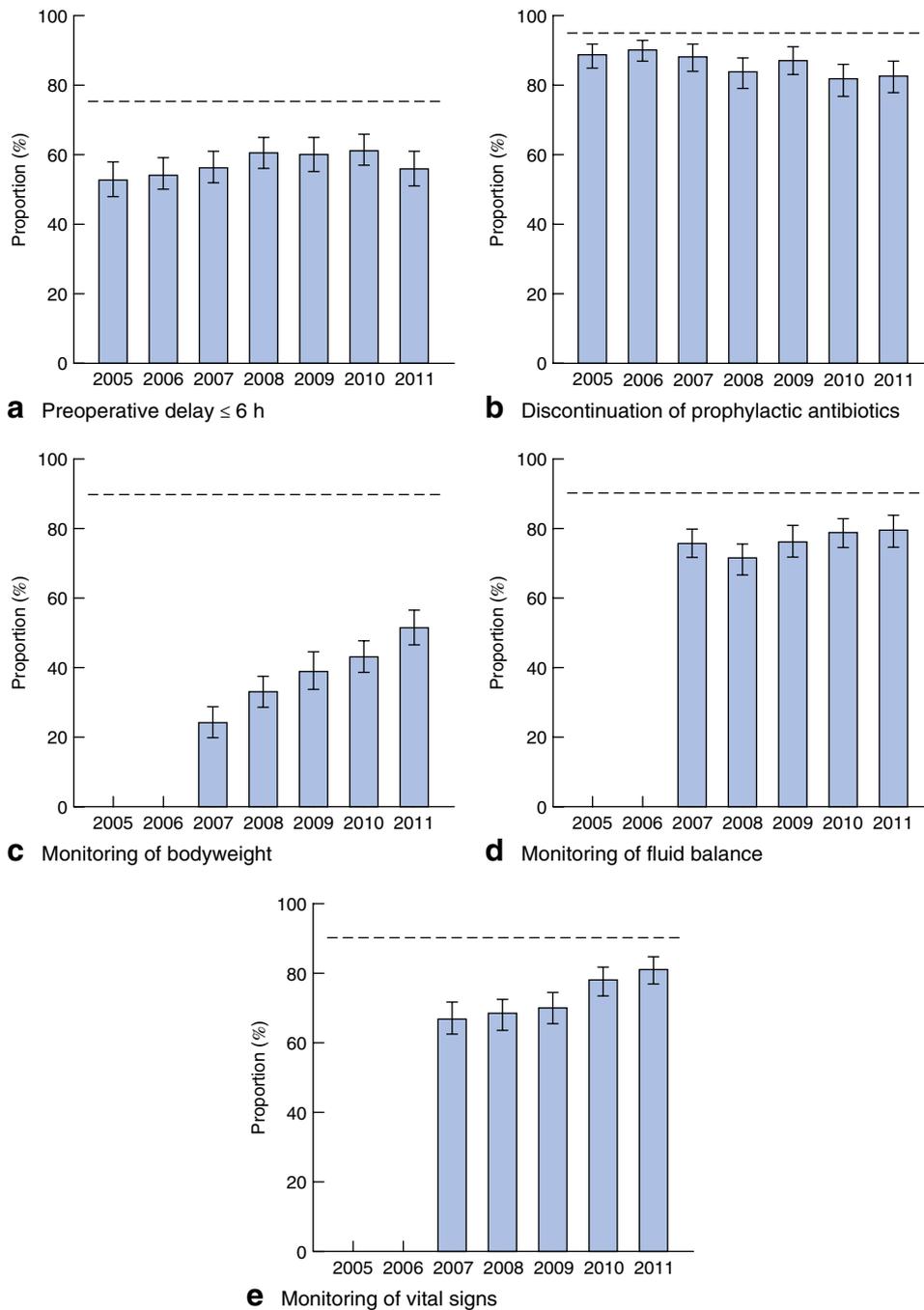


Fig. 2 Quality-of-care process indicators in 2989 patients who had surgery for peptic ulcer perforation in Denmark, 2005–2011: **a** preoperative delay no more than 6 h, **b** discontinuation of prophylactic antibiotics, **c** monitoring of bodyweight, **d** monitoring of fluid balance and **e** monitoring of vital signs. The proportion of patients who fulfilled each quality indicator is shown with 95 per cent confidence interval. Dashed lines show the currently desired quality standard for each indicator

Table 3 Changes over time in fulfilment of the five process-of-care indicators: comparison of results between the most recent 2 years and the first 2 years of monitoring

	Relative risk					
	Delay \leq 6 h*	Prophylactic antibiotics*	Bodyweight†	Fluid balance†	Vital signs†	All or none†
First 2 years	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)
Last 2 years	1.10 (1.01, 1.19)	0.92 (0.88, 0.97)	1.63 (1.43, 1.86)	1.07 (1.02, 1.13)	1.17 (1.10, 1.24)	1.43 (1.20, 1.71)

Values in parentheses are 95 per cent confidence intervals. First 2 years of monitoring: *2005 and 2006, †2007 and 2008.

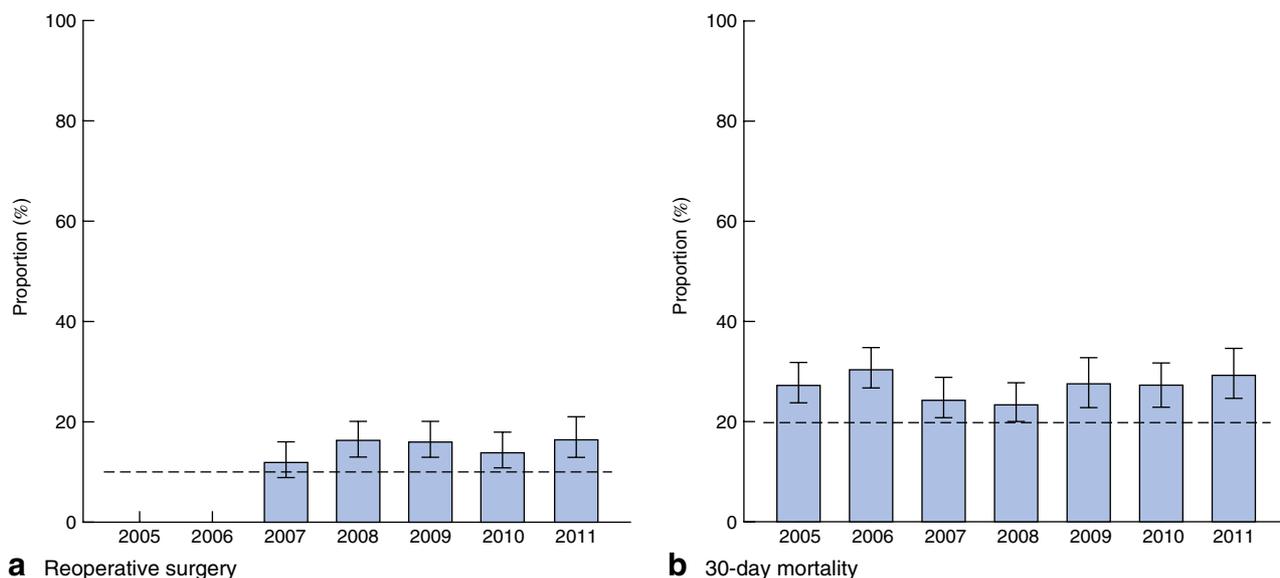


Fig. 3 Quality-of-care outcome indicators in 2989 patients who had surgery for peptic ulcer perforation in Denmark, 2005–2011: **a** reoperative surgery and **b** 30-day mortality. The proportion of patients who fulfilled each quality indicator is shown with 95 per cent confidence interval. Dashed lines show the currently desired quality standard for each indicator

Table 4 Changes over time for reoperative surgery and 30-day mortality: comparison of results between the most recent 2 years and the first 2 years of monitoring

	<i>n</i>	No. with outcome*	Crude relative risk†	Adjusted relative risk†‡
Reoperative surgery				
2007–2008	854	128 (15.0)	1.00 (reference)	1.00 (reference)
2010–2011	796	127 (16.0)	1.07 (0.85, 1.35)	0.98 (0.78, 1.23)
30-day mortality				
2005–2006	959	288 (30.0)	1.00 (reference)	1.00 (reference)
2010–2011	796	231 (29.0)	0.98 (0.85, 1.14)	0.87 (0.76, 1.00)

Values in parentheses are *percentages and †95 per cent confidence intervals. ‡Adjusted for changes over time in sex, age, body mass index, coexisting diseases, smoking, alcohol abuse, and use of aspirin, steroids, non-steroidal anti-inflammatory drugs, selective serotonin reuptake inhibitors and anticoagulants.

per cent (798 of 2989 patients), and thus higher than the QOC standard of maximum 20 per cent (*Fig. 3b*). Importantly, when controlling for changes in prognostic factors over time, a statistically non-significant decrease in 30-day mortality was found (adjusted RR 0.87, 0.76

to 1.00) (*Table 4*). The proportion of patients fulfilling all five QOC process indicators clearly increased over time (RR 1.43, 1.20 to 1.71) (*Fig. 4, Table 3*). Interdepartmental variation remained considerable in 2011, and the number of departments treating PPU decreased over time as

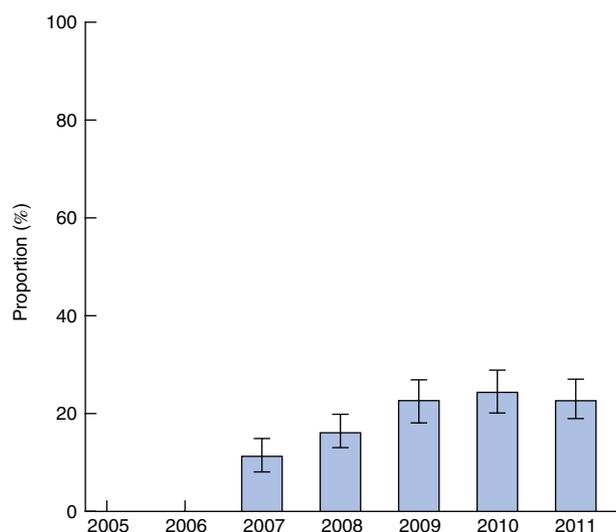


Fig. 4 Rate of fulfilment of all five care process indicators in 2989 patients who had surgery for peptic ulcer perforation in Denmark, 2005–2011. The proportion of patients is shown with 95 per cent confidence interval

a consequence of mergers of Danish hospitals and administrative regions (*Fig. S1*, supporting information).

Discussion

In this nationwide cohort study comprising almost 3000 patients treated surgically for PPU in Denmark from 2005 to 2011, a quality improvement initiative was associated with generally improved QOC. Together with improved fulfilment of most QOC indicators, the 30-day mortality rate decreased by 13 per cent, although not statistically significantly, whereas the need for reoperative surgery remained constant.

The strengths of the present study include its size, the nationwide population-based design, the complete follow-up for ascertainment of survival, and the adjustment for a wide range of potential confounders when assessing clinical outcome indicators. Data collected during routine clinical work may be inaccurate and incomplete. However, participation in the DCRES is mandatory for all departments in Denmark caring for patients with PPU, and extensive efforts are made to ensure the validity of the data¹¹. A structured audit process is carried out nationally, regionally and locally to assess the quality of the data set and results. To ensure completeness of patient registration in the database, it is compared regularly with local hospital discharge registries; estimated registration completeness in 2011 was between 93 and 99 per cent in the five Danish administrative regions.

Some patient records had missing data for prognostic characteristics, particularly in the early years. To control for possible bias by increased confounder completeness over time, multiple imputation was done¹⁷. Adjustment for a wide range of individual prognostic predictors, including detailed information about coexisting diseases, clinical characteristics, and the baseline risk of death through registration of ASA score, was done. Still, some residual confounding by unmeasured factors cannot be excluded.

A reduction in the use of aspirin, NSAIDs and steroids was observed. It is well documented that use of preadmission NSAIDs and steroids is associated with increased mortality after PPU^{5,10,20}. The pathophysiological reason may be the analgesic and anti-inflammatory effects that may blur the symptoms of perforation and delay diagnosis, and the immunosuppressive action (steroids) that may increase the risk of pyogenic infections²⁰. Both of these may lead to an increased risk of sepsis, the leading cause of death after PPU^{21,22}. Hence, the reduced use of aspirin, NSAIDs and steroids should be expected to lead to a reduction in mortality over time. In contrast, co-morbidity has been associated with increased mortality. Limited data exist on the exact association between ASA score level and mortality following PPU, yet ASA III–V seems to be associated with a threefold to fourfold increase in mortality¹⁰. Diabetic patients with PPU have a 50 per cent increased adjusted risk of death compared with non-diabetics²³. An association between PPU and cardiovascular disease has also been suggested¹⁰. The substantial increase in the proportion of patients with diabetes, heart disease and other chronic disease, and in the proportion of patients graded ASA III in the study interval, would be expected to lead to higher mortality from PPU over time.

An unexpectedly high 30-day mortality was noted in the first year of monitoring. Consequently, QOC and treatment of PPU in Denmark received increased attention from regional, national and international organizations²⁴. The core of the quality improvement initiative was increased attention on the perioperative treatment of PPU: a reduction in preoperative delay, early source control, awareness of postoperative fluid balance and nutrition, and adequate postoperative observation. In view of the successive improvements in many of the QOC process indicators, it is disappointing that the high 30-day mortality rate and risk of reoperative surgery remained little changed. This may indicate that either the chosen process indicators are not crucial prognostic factors, or a substantial reduction in mortality is unlikely because mortality is predominantly related to non-modifiable patient characteristics.

Increased preoperative delay is a well established negative prognostic factor for outcome in PPU^{25–29};

prolonged delay carries a four to five times increased risk of death¹⁰. Empirical broad-spectrum antibiotics are of paramount importance in the treatment of peritonitis, and each hour of delay in administration of effective antibiotics is associated with a measurable increase in mortality^{30,31}. The present QOC process indicator 'discontinuation of prophylactic antibiotics' does not focus on the timing of antibiotic administration. As a consequence, the DCRES indicator group has recently revised this indicator, now focusing on timely preoperative antibiotic administration.

Monitoring bodyweight and fluid balance were chosen as separate QOC criteria, because regular weight measurement and a fluid balance chart are the two fundamental elements of assessing hydration/fluid status and nutritional status in surgical patients^{32–35}. Although monitoring bodyweight and fluid balance did not improve outcomes, adequate monitoring of nutritional status and hydration status remains essential if appropriate therapy is the goal.

It is well recognized that abnormal physiology predicts adverse clinical outcomes³⁶. Sixty per cent of adverse outcomes (deaths, cardiac arrests and unplanned admissions to intensive care) are preceded by documented abnormal physiology³⁷, and mortality increases with the number of physiological abnormalities (0.7 per cent with no abnormalities, 4.4 per cent with 1, 9.2 per cent with 2, and 21.3 per cent with 3 or more)³⁸. Without sufficient awareness and documentation of abnormal vital signs and relevant clinical action, outcome cannot be expected to improve³⁹. Structured postoperative risk stratification and electronic automated advisory vital sign monitors could prove successful in the future⁴⁰.

Thus, even though not all process indicators in the DCRES are based on high-level evidence, they seem to address relevant prognostic areas in the treatment of PPU. Continuous critical evaluation and revision of existing QOC indicators is important, particularly in the light of the lack of improvement in clinical outcome. Consequently, three new QOC indicators have been added from 2012 onwards: daily screening for sepsis, observation for more than 12 h in the high-dependency unit/recovery room before admission to the surgical ward, and *Helicobacter pylori* eradication. The potential effect of these new indicators will be evident only in future years.

In a recent controlled multicentre trial using external controls, surgically treated patients with PPU were treated according to a multimodal and multidisciplinary evidence-based perioperative care protocol. This led to a reduction in 30-day mortality of more than one-third⁴¹. Even though this finding needs to be confirmed in other settings, it suggests that PPU mortality is not inevitably high, but may

be reduced with use of a comprehensive interventional perioperative care protocol.

Contributors

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Disclosure

The authors declare no conflict of interest.

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Supporting information

Additional supporting information may be found in the online version of this article:

Fig. S1 Variation in quality-of-care indicators in all Danish departments treating patients with perforated peptic ulcer (Word document)