The day of week of elective colorectal cancer surgery has no impact on mortality and morbidity

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ABSTRACT

INTRODUCTION: Recent studies have reported an association between the day of week of surgery and post-operative mortality, meaning that patients undergoing surgery at the end of the week or during weekends may be at higher risk. The aim of this study was to investigate the influence of the day of week of surgery on mortality and morbidity rates in a national Danish cohort of patients undergoing major elective surgery for colorectal cancer.

METHODS: In a register-based study design, all patients undergoing elective major surgery for colorectal cancer in Denmark during a ten-year period (2005-2014) were studied. Patients were identified in the National Colorectal Cancer Database. Any associations between short-time mortality and morbidity rates within 30 days after operation and the day of week of surgery, as well as patient characteristics, treatment data and socioeconomic data were analysed.

RESULTS: We were unable to show that the day of week had a significant impact on short-term mortality or on surgical or medical complications. There was no evidence that patients undergoing surgery on Fridays had more risk factors or were more socioeconomically deprived than patients undergoing surgery from Monday to Thursday.

CONCLUSIONS: The day of week of operation could not be shown to have any significant impact on the risk of post-operative surgical or medical complications or on short-term mortality in patients undergoing elective surgery for colorectal cancer in Denmark.

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Every year, nearly 5,000 patients are diagnosed with colorectal cancer in Denmark, roughly 85% of whom will undergo surgery as curative or palliative treatment [1]. Previous studies have suggested that mortality after various types of surgery may be higher during weekends than on weekdays [2-5]. In colorectal surgery, a recent study from England found higher post-operative mortality rates (30 days, 90 days, and one year) in elective cases operated on Fridays than in patients operated on Mondays to Thursdays. The study also showed that patients having surgery on Fridays were often more socioeconomically deprived than the other patients; however, in a propensity-score matched analysis, the odds ratios for post-operative mortality were significantly higher on Fridays than on other weekdays [6]. The aim of this study was to investigate the post-operative mortality and morbidity rates, and their association, if any, with the day of week the surgery took place in a national Danish cohort of patients who underwent major elective surgery for colorectal cancer.

METHODS

Patients diagnosed with colorectal cancer during a ten-year period (2005-2014) were identified in the National Colorectal Cancer Database, managed by the Danish Colorectal Cancer Group (DCCG). The database is considered to have an overall patient completeness > 95%, and since 2010 its completeness has been 99% [7]. Data on socioeconomic status (SES) was available from national registers provided by Statistics Denmark [8, 9]. The linkage between these datasets was the unique personal identification number (CPR number) assigned to all Danish residents at birth or immigration by the Danish Civil Registration System [10].

Patients registered in the DCCG database with elective major colorectal surgery, i.e. right-sided hemicolectomy, total colectomy, abdominoperineal excision of the rectum, etc., were included in our analysis, except for patients who underwent minor procedures (explorative procedures, shunting procedures or endoscopic procedures), had missing Union for International Cancer Control (UICC) stage or who underwent surgery on a Saturday or Sunday. Patient characteristics (sex, age, UICC stage, and Charlson Comorbidity Index [11]) as well as treatment data were available from the DCCG database. In the database, prospectively collected data regarding post-operative complications within 30 days from surgery are available. Surgical complications comprise bleeding, burst abdomen, ileus, superficial and/or deep infection, stoma-related complications and anastomotic leakage, whereas medical complications comprise thromboembolic events (venous thromboembolism, stroke, acute myocardial infarction, arterial embolism), aspiration, pneumonia, heart and/or lung

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and/or kidney failure, and sepsis. Data on patients' housing status (rental/owner-occupied), cohabitant status (single/living with partner), education level and gross household income in Danish kroner were available from Statistics Denmark. Data regarding the individual education level were classified according to the International Standard Classification of Education (ISCED) by the United Nations' Educational, Scientific and Cultural Organization (UNESCO) [12]. Patients were thus categorised into three classes; short education (ISCED level 0-2), medium education (ISCED level 3-5), higher education (ISCED level 6-8) and Unknown (ISCED level 9). The annual gross household income was calculated as an average of the annual income in the past five years leading up to the year of diagnosis (including the year of diagnosis). Annual income was corrected for inflation during the study period using an inflation index provided by Statistics Denmark, and patients were divided into four groups by the quartiles (low, mid-low, mid-high and high income).

Our primary goal was to analyse the crude mortality rates by any cause post-operatively by the day of week the surgery was performed. Our second goal was to investigate whether the day of surgery influenced 30-day morbidity such as post-operative surgical or medical complications; however, to ensure homogeneous and consistent data on complications, we used patients only from the years 2010-2014 for this purpose, as the DCCG dataset was changed and improved in 2009.

The study was approved by the Danish Colorectal Cancer Group and the Danish Data Protection Agency (record no. 17/1942).

Statistical methods

The day of surgery was based on the date the surgery took place, and patients were divided into five groups by the day of week (Monday to Friday). Categorical data were analysed with the chi-squared test or Fisher's exact test as appropriate. Pairwise post-hoc comparisons in variables with multiple levels were not made. 30-day mortality and morbidity are defined by the DCCG database as an event occurring within 30 days after surgery. In a sub-analysis focusing on early mortality (defined as death within the first three days, including the day of surgery), patients were grouped into those having surgery on Monday-Wednesday versus those who had surgery on Thursday-Friday. Overall survival was defined as the time in days between the date of surgery and the date of death. The observation time for all patients was at least one year. Surviving patients were right censored on 12 June 2016. The survival function within the first post-operative year was described with Kaplan Meier estimates, and the log-rank test was used to compare the hazard function between the weekdays. In order to characterise the typical "Friday patient", a multiple logistic regression analysis was made using the binary predictor Friday versus Monday-Thursday as dependent variable and patient characteristics with $p \leq 0.20$ in the univariate analysis as independent variables. The results were reported as adjusted odds ratios (OR) with 95% confidence intervals (CI). Missing data were excluded in the univariate analysis, but coded as unknown in the regression analysis if the variable was included. Statistical analysis was performed using Stata 14.2/MP (StataCorp LP, 4905 Lakeway Drive, College Station, Texas, USA) and $p < 0.05$ were considered significant.

Trial registration: not relevant.

RESULTS

A total of 30,087 patients from the years 2005-2014 were identified in the National Colorectal Cancer Database as having had elective surgery. In total, 3,211 of these patients were excluded; 2,579 patients with only minor surgery, 476 patients with missing UICC stage, two patients with obvious registration errors (death date prior to surgery date) and 154 patients who had undergone surgery on Saturdays and Sundays. Thus, 26,876 patients were eligible for further analysis. Patient characteristics are presented in **Table 1**.

Post-operative mortality

The 30-day mortality rate was 3.4% for all patients. Split by the day of surgery, rates were 3.0% for cases operated on Mondays, 3.4% on Tuesdays, 3.5% on Wednesday, 3.4% on Thursdays and 3.6% on Fridays. No overall association between day of surgery and 30-day mortality was seen ($p = 0.52$). Sub-analysis focusing on early mortality found the rates to be 0.28% and 0.27%, respectively, in the two groups ($p = 0.88$). During the ten-year period, 2005-2014, the 30-day mortality rates were decreasing for all five weekdays (**Figure 1**).

The median time of observation was 47 months (range: 0-137 months) and the overall crude survival in the first post-operative year after elective colorectal cancer surgery according to the day of surgery is illustrated in **Figure 2**. The log-rank test showed no differences in one-year mortality and the day of surgery ($p = 0.60$).

Post-operative morbidity within 30 days after surgery

A total of 13,797 patients from the calendar years 2010-2014 had information about surgical complications. The crude rates regarding post-operative surgical complications within 30 days after surgery were; Monday 19.7%, Tuesday 19.3%, Wednesday 19.4%, Thursday 20.9% and Friday 20.3%. No significant differences were found in rates between day of surgery and post-operative surgical complications ($p = 0.52$).

TABLE 1

Baseline characteristics of patients, n (%).

	Monday (n = 6,572)	Thursday (n = 6,479)	Wednesday (n = 5,618)	Thursday (n = 4,885)	Friday (n = 3,322)	All patients (N = 26,876)
Sex						
Female	3,005 (45.7)	3,009 (46.4)	2,545 (45.3)	2,279 (46.7)	1,616 (48.6)	12,454 (46.3)
Male	3,567 (54.3)	3,470 (53.6)	3,073 (54.7)	2,606 (53.3)	1,706 (51.4)	14,422 (53.7)
Age						
≤ 70 yrs	3,360 (51.1)	3,238 (50.0)	2,940 (52.3)	2,460 (50.4)	1,683 (50.7)	13,681 (50.9)
> 70 yrs	3,212 (48.9)	3,241 (50.0)	2,678 (47.7)	2,425 (49.6)	1,639 (49.3)	13,195 (49.1)
Site of cancer						
Colon	4,453 (67.8)	4,306 (66.5)	3,270 (58.2)	3,240 (66.3)	2,352 (70.8)	17,621 (65.6)
Rectum	2,119 (32.2)	2,173 (33.5)	2,348 (41.8)	1,645 (33.7)	970 (29.2)	9,255 (34.4)
Co-morbidity						
0	4,188 (63.7)	4,067 (62.8)	3,594 (64.0)	3,081 (63.1)	2,089 (62.9)	17,019 (63.3)
1-2	1,772 (27.0)	1,787 (27.6)	1,501 (26.7)	1,373 (28.1)	896 (27.0)	7,329 (27.3)
≥ 3	612 (9.3)	625 (9.6)	523 (9.3)	431 (8.8)	337 (10.1)	2,528 (9.4)
Surgical approach						
Open surgery	3,091 (47.0)	3,008 (46.4)	2,760 (49.1)	2,334 (47.8)	1,520 (45.8)	12,713 (47.3)
Laparoscopic	3,481 (53.0)	3,471 (53.6)	2,858 (50.9)	2,551 (52.2)	1,802 (54.2)	14,163 (52.7)
Year of surgery						
2005	544 (8.3)	626 (9.7)	588 (10.5)	486 (9.9)	256 (7.7)	2,500 (9.3)
2006	600 (9.1)	662 (10.2)	571 (10.2)	429 (8.8)	324 (9.8)	2,586 (9.6)
2007	609 (9.3)	657 (10.1)	568 (10.1)	457 (9.4)	282 (8.5)	2,573 (9.6)
2008	562 (8.6)	693 (10.7)	545 (9.7)	455 (9.3)	264 (7.9)	2,519 (9.4)
2009	691 (10.5)	604 (9.3)	519 (9.2)	455 (9.3)	308 (9.3)	2,577 (9.6)
2010	677 (10.3)	616 (9.5)	499 (8.9)	481 (9.8)	313 (9.4)	2,586 (9.6)
2011	659 (10.0)	647 (10.0)	578 (10.3)	459 (9.4)	333 (10.0)	2,676 (10.0)
2012	728 (11.1)	621 (9.6)	547 (9.7)	518 (10.6)	384 (11.6)	2,798 (10.4)
2013	718 (10.9)	628 (9.7)	547 (9.7)	542 (11.1)	385 (11.6)	2,820 (10.5)
2014	784 (11.9)	725 (11.2)	656 (11.7)	603 (12.3)	473 (14.2)	3,241 (12.1)
ISCED						
Short education	2,524 (38.4)	2,525 (39.0)	2,171 (38.6)	1,936 (39.6)	1,279 (38.5)	10,435 (38.8)
Medium education	2,784 (42.4)	2,667 (41.2)	2,222 (39.6)	1,960 (40.1)	1,353 (40.7)	10,986 (40.9)
Long education	977 (14.9)	976 (15.1)	941 (16.7)	789 (16.2)	556 (16.7)	4,239 (15.8)
Unknown	287 (4.4)	311 (4.8)	284 (5.1)	200 (4.1)	134 (4.0)	1,216 (4.5)
Housing status						
Rental	2,468 (38.2)	2,426 (38.2)	2,174 (39.4)	1,823 (38.1)	1,260 (38.3)	10,151 (38.3)
Owner	3,997 (61.8)	3,921 (61.8)	3,346 (60.6)	2,965 (61.9)	2,033 (61.7)	16,262 (61.3)
Unknown	–[b]	–[b]	–[b]	–[b]	–[b]	113 (0.4)
Cohabitant status						
Cohabitant	4,285 (65.4)	4,128 (63.9)	3,611 (64.5)	3,159 (64.8)	2,098 (63.3)	17,281 (64.3)
Single	2,266 (34.6)	2,337 (36.1)	1,988 (35.5)	1,714 (35.2)	1,217 (36.7)	9,522 (35.4)
Unknown	–[b]	–[b]	–[b]	–[b]	–[b]	73 (0.3)
Gross household income, DKK						
< 178.000	1,584 (24.2)	1,603 (24.9)	1,372 (24.6)	1,208 (24.8)	825 (24.9)	6,592 (24.5)
178.000-262.000	1,580 (24.2)	1,630 (25.3)	1,395 (25.0)	1,233 (25.4)	826 (24.9)	6,664 (24.8)
262.000-400.000	1,694 (25.9)	1,604 (24.9)	1,378 (24.7)	1,228 (25.3)	787 (23.8)	6,691 (24.9)
> 400.000	1,681 (25.7)	1,613 (25.0)	1,443 (25.8)	1,193 (24.5)	874 (26.4)	6,804 (25.3)
Unknown	–[b]	–[b]	–[b]	–[b]	–[b]	125 (0.5)

CONTINUES »

TABLE 1 CONTINUED

	Monday (n = 6,572)	Thursday (n = 6,479)	Wednesday (n = 5,618)	Thursday (n = 4,885)	Friday (n = 3,322)	All patients (N = 26,876)
UICC stage						
I	1,227 (18.7)	1,184 (18.3)	1,133 (20.2)	914 (18.7)	599 (18.0)	5,057 (18.8)
II	2,541 (38.7)	2,457 (37.9)	2,088 (37.2)	1,797 (36.8)	1,308 (39.4)	10,191 (37.9)
III	1,981 (30.1)	1,991 (30.7)	1,665 (29.6)	1,507 (30.8)	1,005 (30.3)	8,149 (30.3)
IV	823 (12.5)	847 (13.1)	732 (13.0)	667 (13.7)	410 (12.3)	3,479 (12.9)
Surgical complications[a]						
Yes	683 (19.7)	612 (19.3)	536 (19.4)	532 (20.9)	375 (20.3)	2,738 (19.8)
No	2,793 (80.3)	2,558 (80.7)	2,231 (80.6)	2,008 (79.1)	1,469 (79.7)	11,059 (80.2)
Medical complications[a]						
Yes	322 (9.3)	299 (9.4)	278 (10.1)	249 (9.8)	182 (9.9)	1,330 (9.6)
No	3,149 (90.7)	2,872 (90.6)	2,484 (89.9)	2,291 (90.2)	1,662 (90.1)	12,458 (90.4)
30-day mortality						
Dead	199 (3.0)	222 (3.4)	197 (3.5)	165 (3.4)	119 (3.6)	902 (3.4)
Alive	6,373 (97.0)	6,257 (96.6)	5,421 (96.5)	4,720 (96.6)	3,203 (96.4)	25,974 (96.6)

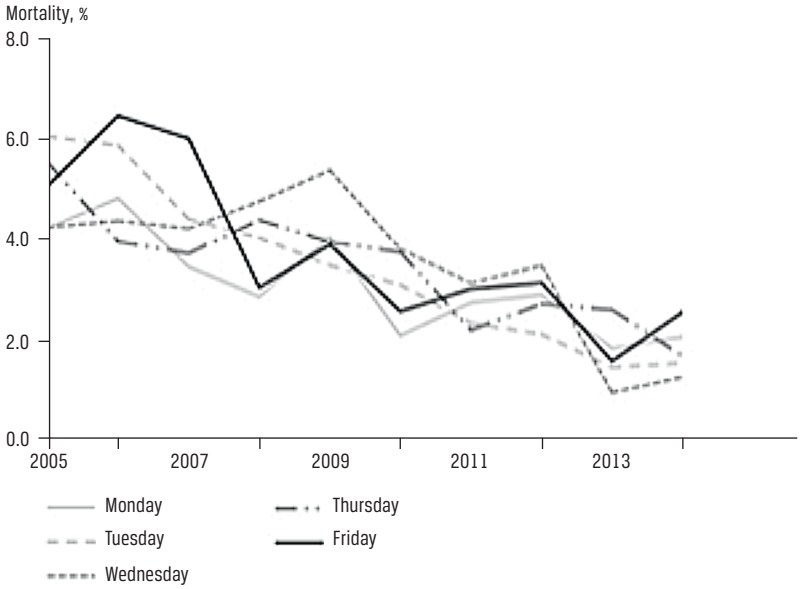
ISCED = International Standard Classification of Education; UICC = Union for International Cancer Control.
a) As defined by the Danish Colorectal Cancer Group. Data not available from the years 2005-2009.
b) Data not shown due to small number of observations in each cell according to discretional guidelines from Statistics Denmark.

In all, 13,788 patients from the calendar years 2010-2014 had information regarding medical complications within 30 post-operative days.

The crude morbidity rates were; Monday 9.3%, Tuesday 9.4%, Wednesday 10.1%, Thursday 9.8%, and Friday 9.9%. No significant association was found between day of surgery and medical complications ($p = 0.84$).

FIGURE 1

The 30-day mortality rates decreased over the years.



Characteristics of patients undergoing surgery on Fridays

In the univariate analysis, sex, site of cancer, surgical approach, year of surgery and cohabitant status were associated with having surgery on Fridays compared with Monday-Thursday. In the multivariate logistic regression model, colon cancer (OR = 1.29 (95% CI: 1.19-1.40); $p < 0.0001$) and year of surgery (OR: 1.04 (95% CI: 1.03-1.06); $p < 0.0001$) were the only significant predictors for having surgery on a Friday.

DISCUSSION

Over the years, many authors have investigated the possible "Friday effect" or "weekend effect" with various findings [2-6, 13, 14]. In a recent systematic review and meta-analysis including more than five million elective patients from different surgery specialities, the ORs for post-operative mortality increased from Monday to Friday [15]. The present population-based study, however, revealed no association between the day of week of surgery and either 30-day mortality or one-year crude overall survival. Our analysis was based on a homogeneous group of patients undergoing elective colorectal cancer surgery with any kind of bowel resection and thus considered major procedures. Over the past couple of decades, colorectal cancer surgery in Denmark has been centralised to larger and more specialised centres [16], and there has been a strong political focus on cancer treatment. The 30-day post-operative mortality in Denmark has decreased markedly [17], and in 2014 the rate was less than 2% after elective colorectal surgery [1].

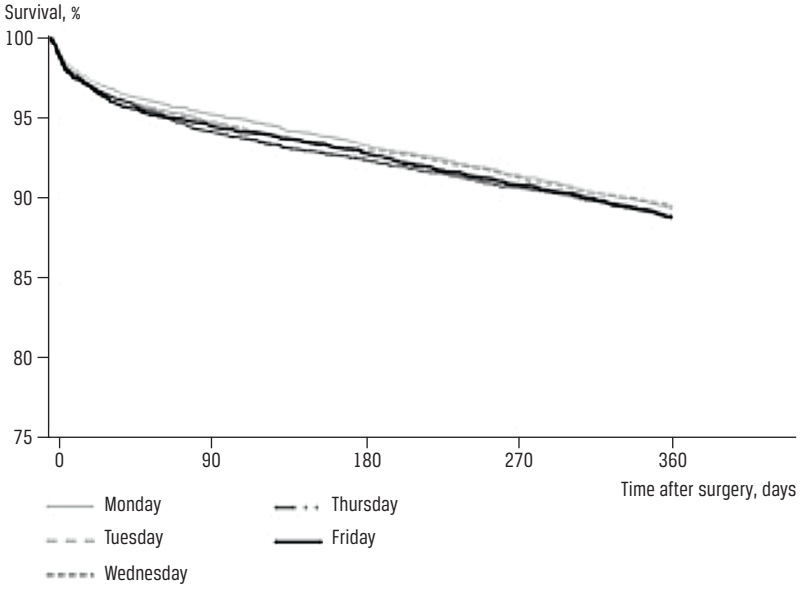
Data regarding complications was available for the calendar years 2010-2014, albeit without the Clavien-Dindo score [18] implemented in Denmark from 2014. Complications and mortality were treated as independent outcomes in this study, and the possible relationship between them was not investigated. We found no significant association between the day of surgery and the rate of post-operative surgical or medical complications.

An often proposed explanation for a "day of week" effect is that for patients undergoing surgery at the end of the week, the first critical post-operative days coincide with a weekend during which the staffing levels are lower and perhaps the staff members present are less experienced. To elucidate this, we analysed variation in mortality rates within 72 hours of operation (including the day of surgery) and found no difference in early mortality when grouping patients into Monday-Wednesday versus Thursday-Friday. Furthermore, in two recent studies, surgeon experience had no significant association with post-operative mortality regarding the day of week of surgery [13, 14]. Still, other structural factors may influence mortality, and one important finding made in the study by Zare et al was the significantly higher mortality rate in patients treated on Fridays, if the patient was sent to a regular floor post-operatively rather than to intensive care or being discharged home directly [2].

Most of the previous studies have included a rather heterogeneous case mix of patients from different surgical specialities; however, Vohra et al focused on elective colorectal patients (albeit benign as well as malignant cases), and did, in fact, report a significant "Friday effect". An interesting finding in that study, however, was that patients undergoing surgery on Fridays were more socioeconomically deprived than patients having surgery earlier in the week using an aggregated deprivation score [6]. In our study, on the other hand, education level, gross household income, housing and cohabitant status were used as separate measures of SES, and this should be kept in mind when comparing with other studies. We were unable to establish any evidence to support that patients who underwent surgery on Fridays were more deprived than the other patients, nor did we find any differences in other patient characteristics associated with mortality and morbidity such as age, co-morbidity, gender and cancer stage. Thus, we found no evidence of social inequality in the selection of the day of week for elective colorectal cancer surgery. We did find that the typical Friday patient had a greater likelihood of having colon cancer than rectal cancer. Any potential bias, however, would only strengthen our conclusion, since mortality after elective surgery for colon cancer exceeds that of rectal cancer [19].

FIGURE 2

Kaplan-Meier curves with one-year overall survival after elective colorectal surgery, by day of surgery.



The strength of our study is that we have a national cohort of Danish colorectal cancer patients who had major elective bowel resection surgery and have linked these patients on an individual basis to other national registers holding socioeconomic data. The limitations of our study include its retrospective register-based design and the relatively small size of our country; thus, even a nationwide population of a decade of colorectal cancer patients constitute a relatively small cohort compared with other similar studies and may thus potentially lack statistical power.

CONCLUSIONS

We found no significant evidence that the day of week the surgery took place is associated with the risk of short-term post-operative morbidity or mortality in colorectal cancer patients undergoing major elective bowel resection surgery in Denmark.

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