ORIGINAL RESEARCH

Weekday and Survival After Cardiac Surgery—A Swedish Nationwide Cohort Study in 106 473 Patients

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***Background*—**The purpose of this study was to investigate the association between weekday of surgery and survival following cardiac surgery.

***Methods and Results*—**In a nationwide cohort study, we included all patients who underwent cardiac surgery in 1999–2013 from the SWEDEHEART (Swedish Web-system for Enhancement and Development of Evidence-based care in Heart disease Evaluated According to Recommended Therapies) register. All-cause mortality until March 2014 was obtained from national registers. The association between weekday of surgery and mortality was estimated using Cox regression, and reported as hazard ratios with 95% CI. We used the restricted mean survival time difference to estimate loss of life related to weekday of surgery. Among 106 473 patients, 25 221 (24%), 24 471 (23%), 22 977 (22%), 20 189 (19%), 9251 (8.7%), and 4364 (4.1%) underwent surgery during a Monday, Tuesday, Wednesday, Thursday, Friday, and a Saturday/Sunday, respectively. More patients were operated on urgently during Friday to Sunday, and unadjusted analyses showed higher early and late mortality in those patients. The adjusted hazard ratios (95% CI) were 1.00 (0.89–1.13), 1.00 (0.88–1.12), 1.02 (0.90–1.16), 1.17 (1.01–1.37), and 1.05 (0.86–1.29) in patients who underwent surgery during a Tuesday, Wednesday, Thursday, Friday, and Saturday/Sunday compared to a Monday, after 1 year of follow-up conditional on 30-day survival. In elective surgery (n=46 146), the 1-year restricted mean survival time difference (95% CI) was −0.5 (−1.8–0.8), −0.5 (−1.9–0.8), −1.0 (−2.6–0.5), 0.02 (−2.2–2.3), and −1.2 (−6.3–3.9) days in patients who underwent surgery during a Tuesday, Wednesday, Thursday, Friday, and a Saturday/Sunday, respectively, compared to a Monday.

***Conclusions*—**We found no evidence of a clinically relevant weekday effect in patents who underwent cardiac surgery in Sweden during a 15-year period. These data suggest that the early risk and long-term prognosis following cardiac surgery was not affected by the weekday of surgery.

***Clinical Trial Registration*—**URL: http://www.clinicaltrials.gov. Unique identifier: NCT02276950. **(*J Am Heart Assoc*. 2017;6: e005908. DOI: 10.1161/JAHA.117.005908.)**

Key Words: cardiac surgery • long-term outcome • quality of care • risk factors • weekday effect

Studies have suggested that weekday of surgery influences survival after major surgery such that patients who undergoe surgery late in the week have worse survival compared with those who had surgery early in the week.[1–3] It has been speculated that this association is driven by poorer quality of care and intensity of specialist staffing during the weekend.[1,3–5] Others have suggested surgeon fatigue with subsequent impaired surgical precision later in the week as a possible explanation in particularly demanding procedures such as esophageal cancer surgery.[2] Therefore, we hypothesized that patients who were operated on later in the work week had worse survival compared with those who were operated on early in the week.

Although most reports showed higher short-term mortality in patients who underwent surgery late compared with early in the week,[1,3,6,7] results were conflicting.[8,9] Notably, previous studies investigated only short-term mortality in patients who underwent different types of operations. Very few studies have examined the impact of weekday of surgery on long-term mortality.[2,9] One study found no association between day of the work week and in-hospital death or major short-term morbidity in patients who underwent elective isolated coronary artery bypass graft surgery.[10] No previous

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Accompanying Tables S1 through S4 are available at http://jaha.ahajournals.org/content/6/5/e005908/DC1/embed/inline-supplementary-material-1.pdf

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Received February 18, 2017; accepted April 21, 2017.

Clinical Perspective

What Is New?

- Prior studies have suggested that weekday of surgery influences survival after major surgery, but whether this "weekday" effect is relevant in cardiac surgery is mostly unknown.
- We found no evidence of a clinically relevant weekday effect in patients who underwent cardiac surgery in Sweden, and our findings suggest that the early risk and long-term prognosis following cardiac surgery were not affected by the weekday of surgery.

What Are the Clinical Implications?

- Cardiac surgery can safely be performed on any day of the week without an increase in the risk of short- or long-term mortality.

study known to us has examined possible weekday-related variation in long-term outcomes in cardiac surgery patients.

Therefore, we included all adults who underwent cardiac surgery in Sweden during a 15-year period in a nationwide population-based cohort study to investigate whether outcomes after cardiac surgery are associated with weekday of surgery.

Methods

This was a nationwide population-based observational cohort study that was approved by the regional Human Research Ethics Committee, Stockholm, Sweden (Approval number: 2016/1241-32), and the need for informed consent was waived by the committee.

Study Population and Data Sources

We identified all patients who underwent cardiac surgery in Sweden from the SWEDEHEART (Swedish Web-system for Enhancement and Development of Evidence-based care in Heart disease Evaluated According to Recommended Therapies) register.[11,12] Using unique personal identity numbers, which are assigned to all residents of Sweden,[13] the data from SWEDEHEART were linked with data from other national healthcare registers as previously described.[14,15] The National Patient Register[16] was used to determine relevant medical history, and the Longitudinal integration database for health insurance and labor market studies,[17] managed by Statistics Sweden, was used to obtain details regarding educational level, household disposable income, country of birth, and marital status. The Swedish National Board of Health and Welfare performed the record linkages. The International Classification of Diseases codes used for extraction of medical history and coexisting diagnoses are listed in Table S1.

Weekday and Public Holidays

Patients were assigned to a weekday category corresponding to the date of surgery. In Sweden, ≈17 days per year are established public holidays that are practically equivalent to Sundays. Some public holidays always occur on a Sunday (eg, Easter Sunday), and others (eg, New Year's Day) can occur on any day of the week, depending on the year. For the purpose of this study, we categorized all operations that were performed on a public holiday as a surgery performed on a Sunday. With very few exceptions, only nonelective surgery is performed during weekends (from Friday afternoon to Monday morning).

Outcome Measure

The main outcome measure was time to death from any cause. The Cause of Death Register was used to obtain dates of death.

Statistical Analyses

We categorized patients into groups according to weekday of surgery, with surgery performed on Saturday/Sunday combined with surgery performed on public holidays. Baseline characteristics were described with frequencies and percentages for categorical variables and means and standard deviations for continuous variables. Person–time in days was counted from the date of surgery until the date of death or end of follow-up (March 24, 2014). We reported crude incidence rates and 95% CI, and the Kaplan–Meier method was used to calculate cumulative survival. We used Cox proportional hazards regression with and without multivariable adjustment to estimate hazard ratios (HR) and 95% CI for the association between weekday categories and survival with varying follow-up times using patients having surgery on a Monday as the reference category. All Cox regression models were stratified by calendar year of surgery and hospital. Patient age was modeled using restricted cubic splines, and all other variables were included as categorical terms. We reported the restricted mean survival time[18] by weekday at 1 and 3 years as absolute measures of survival time, and calculated the difference in restricted mean survival time with 95% CI. The difference in restricted mean survival time is a model-free measure that is useful in order to quantify the contrast between 2 survival curves, and can from a clinical perspective be interpreted as loss of life expectancy.

Table 1. Baseline Characteristics in 106 473 Patients Who Underwent Cardiac Surgery in Sweden During 1999 to 2013 According to Weekday of Surgery

	Total Population	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday–Sunday
N (%)	106 473 (100%)	25 221 (24%)	24 471 (23%)	22 977 (22%)	20 189 (19%)	9251 (8.7%)	4364 (4.1%)
Age, y—mean, SD	66.7 (10.9)	67.1 (10.5)	66.9 (10.9)	66.8 (11.1)	66.5 (11.2)	66.2 (10.8)	65.4 (11.6)
Sex							
Men	77 806 (73%)	18 482 (73%)	17 776 (73%)	16 633 (72%)	14 785 (73%)	6955 (75%)	3175 (73%)
Women	28 667 (27%)	6739 (27%)	6695 (27%)	6344 (28%)	5404 (27%)	2296 (25%)	1189 (27%)
Birth region							
Nordic countries	97 625 (92%)	23 263 (92%)	22 363 (91%)	21 057 (92%)	18 457 (91%)	8493 (92%)	3992 (91%)
Other	8848 (8%)	1958 (8%)	2108 (9%)	1920 (8%)	1732 (9%)	758 (8%)	372 (9%)
Education							
<10 y	44 162 (44%)	10 505 (44%)	10 133 (44%)	9577 (44%)	8385 (44%)	3853 (44%)	1709 (41%)
10 to 12 y	38 386 (38%)	9059 (38%)	8784 (38%)	8268 (38%)	7295 (38%)	3331 (38%)	1649 (40%)
>12 y	17 870 (18%)	4287 (18%)	4116 (18%)	3831 (18%)	3346 (18%)	1529 (18%)	761 (18%)
Civil status							
Married	67 807 (64%)	16 072 (64%)	15 688 (64%)	14 621 (64%)	12 864 (64%)	5925 (64%)	2637 (60%)
Other	38 666 (36%)	9149 (36%)	8783 (36%)	8356 (36%)	7325 (36%)	3326 (36%)	1727 (40%)
Household disposable income							
Quartile 1 (lowest)	26 512 (25%)	6167 (25%)	6027 (25%)	5815 (25%)	5028 (25%)	2355 (26%)	1120 (26%)
Quartile 2	26 498 (25%)	6367 (25%)	6141 (25%)	5691 (25%)	5063 (25%)	2222 (24%)	1014 (23%)
Quartile 3	26 505 (25%)	6205 (25%)	6151 (25%)	5655 (25%)	5110 (25%)	2326 (25%)	1058 (24%)
Quartile 4 (highest)	26 505 (25%)	6398 (25%)	6061 (25%)	5724 (25%)	4891 (24%)	2294 (25%)	1137 (26%)
Body mass index, kg/m^2—mean, SD	26.9 (4.2)	26.9 (4.1)	26.9 (4.2)	26.9 (4.2)	26.9 (4.2)	27.0 (4.2)	26.6 (4.2)
Diabetes mellitus	20 883 (20%)	4980 (20%)	4795 (20%)	4474 (19%)	4025 (20%)	1805 (20%)	804 (18%)
Hypertension	32 462 (30%)	7808 (31%)	7501 (31%)	6984 (30%)	6118 (30%)	2818 (30%)	1233 (28%)
Hyperlipidemia	19 079 (18%)	4641 (18%)	4350 (18%)	4104 (18%)	3541 (18%)	1797 (19%)	646 (15%)
Peripheral vascular disease	10 398 (10%)	2371 (9%)	2392 (10%)	2404 (10%)	1965 (10%)	802 (9%)	464 (11%)
eGFR, mL/min per 1.73 m^2							
>60	70 314 (74%)	16 788 (74%)	16 228 (74%)	15 131 (74%)	13 351 (74%)	6186 (75%)	2630 (73%)
45 to 60	16 234 (17%)	3953 (17%)	3724 (17%)	3536 (17%)	3105 (17%)	1346 (16%)	570 (16%)
30 to 45	6104 (6%)	1421 (6%)	1444 (7%)	1352 (7%)	1110 (6%)	502 (6%)	275 (8%)
15 to 30	1255 (1%)	305 (1%)	275 (1%)	261 (1%)	221 (1%)	125 (2%)	68 (2%)
<15*	976 (1%)	176 (1%)	249 (1%)	217 (1%)	206 (1%)	69 (1%)	59 (2%)
Chronic pulmonary disease	7357 (7%)	1762 (7%)	1692 (7%)	1579 (7%)	1394 (7%)	605 (7%)	325 (7%)
Prior myocardial infarction	41 405 (39%)	9544 (38%)	9083 (37%)	8553 (37%)	7818 (39%)	4235 (46%)	2172 (50%)
Prior PCI	12 594 (12%)	2993 (12%)	2861 (12%)	2697 (12%)	2409 (12%)	1085 (12%)	549 (13%)
Heart failure	16 566 (16%)	3794 (15%)	3874 (16%)	3750 (16%)	3262 (16%)	1319 (14%)	567 (13%)
LV ejection fraction, %							
>50	51 057 (69%)	12 448 (70%)	11 806 (69%)	11 034 (70%)	9700 (69%)	4048 (67%)	2021 (65%)
30 to 50	18 486 (25%)	4415 (25%)	4254 (25%)	3929 (25%)	3515 (25%)	1576 (26%)	797 (26%)
<30	4291 (6%)	905 (5%)	931 (5%)	904 (6%)	861 (6%)	397 (7%)	293 (9%)
Stroke	9208 (9%)	2185 (9%)	2085 (9%)	2004 (9%)	1731 (9%)	801 (9%)	402 (9%)
Atrial fibrillation	13 203 (12%)	3187 (13%)	3268 (13%)	2932 (13%)	2549 (13%)	877 (9%)	390 (9%)

Continued

Table 1. Continued

	Total Population	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday–Sunday
Cancer	6491 (6%)	1536 (6%)	1469 (6%)	1467 (6%)	1211 (6%)	538 (6%)	270 (6%)
Alcohol dependency	2116 (2%)	495 (2%)	477 (2%)	441 (2%)	397 (2%)	205 (2%)	101 (2%)
Emergent operation	4994 (7%)	619 (3%)	709 (4%)	732 (5%)	790 (6%)	790 (13%)	1354 (43%)
Waiting time ≤10 d	35 109 (35%)	6689 (28%)	6168 (26%)	6813 (31%)	7378 (38%)	4836 (55%)	3225 (81%)
Operation							
Isolated CABG	66 319 (62%)	15 880 (63%)	14 821 (61%)	13 773 (60%)	12 324 (61%)	6611 (71%)	2910 (67%)
Isolated valve	13 557 (13%)	3413 (14%)	3428 (14%)	3082 (13%)	2551 (13%)	866 (9%)	217 (5%)
Valve+CABG	16 857 (16%)	4146 (16%)	4018 (16%)	3921 (17%)	3371 (17%)	1012 (11%)	389 (9%)
Other	9740 (9%)	1782 (7%)	2204 (9%)	2201 (10%)	1943 (10%)	762 (8%)	848 (19%)

Data are n (%) unless otherwise noted. CABG indicates coronary artery bypass grafting; eGFR, estimated glomerular filtration rate; LV, left ventricular; PCI, percutaneous coronary intervention.
*This category included patients on dialysis.

Missing data (left ventricular ejection fraction [31%], emergent operation [30%], body mass index [12%], renal function [11%], educational level [5.7%], waiting time ≤10 days [4.9%], and disposable income [0.4%]) were handled by multiple imputation by chained equations.[19] The imputation models included all variables in Table 1, year of surgery, hospital, and also the event indicator and the Nelson-Aalen estimator of the cumulative baseline hazard.[20] Ten data sets were imputed and estimates from these data sets were combined according to Rubin's rules. We also repeated the analyses using a missing value indicator category, and finally we performed a complete case analysis.

Data management and statistical analyses were performed using Stata 14.2 (Stata Corp, College Station, TX) and R version 3.3.1 (R Foundation for Statistical Computing, Vienna, Austria).

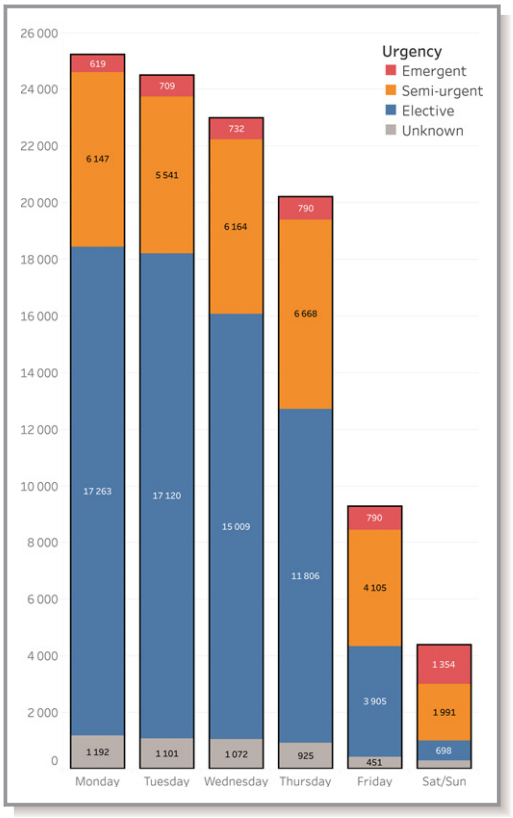

Figure 1. Number of operations per weekday. Number of heart operations performed per weekday in Sweden during 1999 to 2013.

Results

Study Population and Patient Characteristics

Patient characteristics according to weekday category are presented in Table 1. The number of patients operated on each day of the week is shown in Figure 1. A total of 106 473 patients with a mean age of 67 years were included. Of these, 27% were women. The majority (87%) of patients underwent surgery during Monday to Thursday. Patients were categorized according to weekday of surgery: 25 221 (24%), 24 471 (23%), 22 977 (22%), 20 189 (19%), 9251 (8.7%), and 4364 (4.1%) underwent surgery during a Monday, Tuesday, Wednesday, Thursday, Friday, and a Saturday/Sunday, respectively. Patient characteristics were similar across groups with the exception that in relative terms, semi-urgent (waiting time 10 days or less) and emergent surgery were more common during Friday–Sunday (Figure 1).

Follow-Up and Mortality

During a median follow-up time of 6.8 years, a total of 29 806 (28%) patients died: 27%, 28%, 28%, 28%, 28%, and

Table 2. Event Rates and Relative Risks for All-Cause Mortality Following Cardiac Surgery in Sweden During 1999 to 2013 According to Weekday of Surgery

	Number of Deaths/ Person–Y	Unadjusted Mortality Rate Per 1000 Person–Y (95% CI)	Crude HR (95% CI)	Multivariable* Adjusted HR (95% CI)
0 to 30 d follow-up				
Monday	593/2038	291 (268–315)	1.00 (ref)	1.00 (ref)
Tuesday	637/1974	323 (299–349)	1.11 (0.99–1.24)	1.07 (0.95–1.19)
Wednesday	598/1853	323 (298–350)	1.11 (0.99–1.25)	0.99 (0.88–1.11)
Thursday	567/1626	349 (321–379)	1.21 (1.08–1.36)	1.01 (0.90–1.13)
Friday	289/744	389 (346–436)	1.36 (1.18–1.57)	0.98 (0.84–1.13)
Saturday/Sunday	355/337	1053 (949–1169)	3.62 (3.17–4.14)	1.53 (1.32–1.77)
30 d to 1 y follow-up				
Monday	559/21 885	26 (24–28)	1.00 (ref)	1.00 (ref)
Tuesday	558/21 229	26 (24–29)	1.03 (0.92–1.16)	1.00 (0.89–1.13)
Wednesday	542/19 922	27 (25–30)	1.07 (0.95–1.20)	1.00 (0.88–1.12)
Thursday	492/17 452	28 (26–31)	1.11 (0.98–1.25)	1.02 (0.90–1.16)
Friday	257/7917	33 (29–37)	1.30 (1.12–1.51)	1.17 (1.01–1.37)
Saturday/Sunday	130/3538	37 (31–44)	1.42 (1.17–1.72)	1.05 (0.86–1.29)
1 to 15 y follow-up				
Monday	5628/149 442	38 (37–39)	1.00 (ref)	1.00 (ref)
Tuesday	5633/146 465	39 (38–40)	1.02 (0.98–1.06)	1.02 (0.98–1.06)
Wednesday	5374/138 946	39 (38–40)	1.02 (0.99–1.06)	1.01 (0.97–1.05)
Thursday	4635/121 034	38 (37–39)	1.01 (0.97–1.05)	1.02 (0.98–1.06)
Friday	2043/57 018	36 (34–37)	0.94 (0.89–0.99)	1.00 (0.95–1.06)
Saturday/Sunday	908/23 476	39 (36–41)	1.03 (0.96–1.10)	0.98 (0.91–1.06)

HR indicates hazard ratio; ref, reference category.
*Model included all variables reported in Table 1.

32% of patients who were operated during a Monday, Tuesday, Wednesday, Thursday, Friday, and Saturday/Sunday, respectively. The incidence rate, and crude and adjusted relative risks for all-cause mortality are shown in Table 2. The crude HR increased toward the end of the week, although this effect was attenuated with increasing length of follow-up (Figure 2). After multivariable adjustment, only operations carried out on Saturday/Sunday were significantly associated with early mortality (follow-up until 30 days); HR (95% CI) 1.53 (1.32–1.77). For patients who had surgery on Fridays, there was a significantly increased risk of death; adjusted HR (95% CI): 1.17 (1.01–1.37), after 1 year of follow-up conditional on 30-day survival, but this was attenuated after restricting the analytical sample to elective patients operated on during Monday to Friday; adjusted HR (95% CI): 1.08 (0.80–1.46). There was no association between weekday of surgery and mortality after multivariable adjustment in patients followed beyond 1 year and until 15 years (Figure 2).

The adjusted 1-year cumulative mortality (95% CI) was 1.8 (1.7–2.0), 1.9 (1.7–2.1), 1.9 (1.7–2.1), 1.9 (1.7–2.0), 1.9 (1.7–2.1), and 1.9 (1.7–2.2) in patients who were operated on during a Monday, Tuesday, Wednesday, Thursday, Friday, and Saturday/Sunday, respectively (Figure 3).

Patient characteristics were very similar across weekdays, but emergent surgery was more common during Friday–Sunday (Table 1 and Figure 1). The reduction in HR observed in the adjusted compared with the crude analyses was mainly driven by urgency status, and the addition of a wealth of other clinical parameters to the regression model had only a negligible effect on the point estimates. A similar pattern was seen in the restricted mean survival time analyses, where we found no significant differences in the restricted mean survival time between weekdays among patients who underwent elective surgery (Table 3). The difference in survival time ranged from −1.2 days to 0.02 days at 1 year, and −4.7 days to −3.2 days at 3 years, and was not statistically significant at any point.

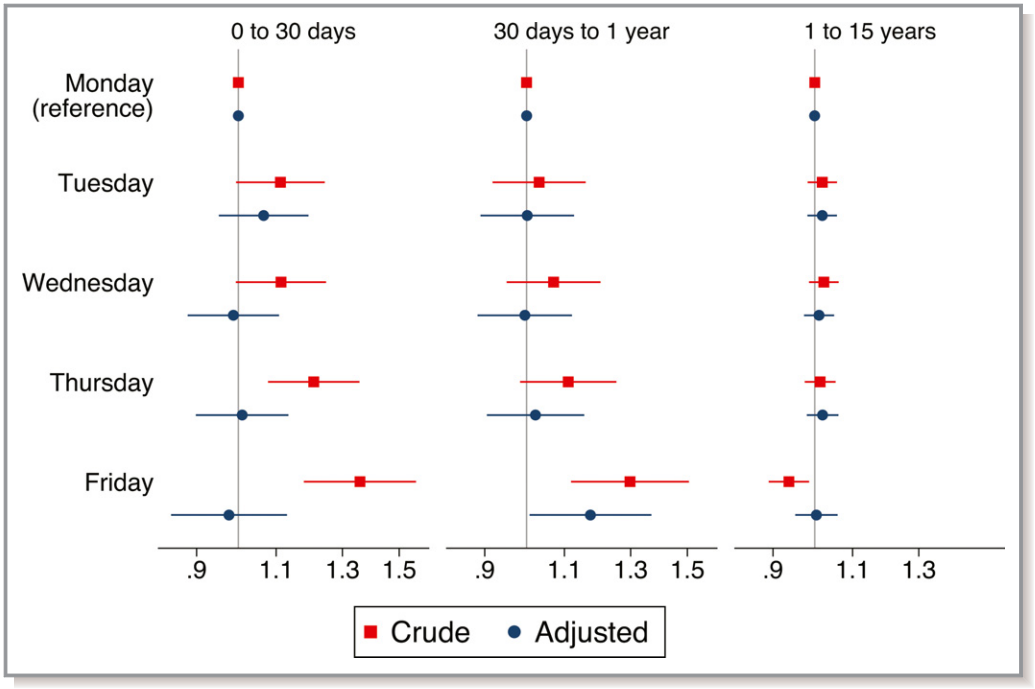

Figure 2. Risk of mortality according to weekday. The crude and multivariable adjusted hazard ratios and 95% CIs for all-cause mortality following cardiac surgery in Sweden during 1999 to 2013 according to weekday of surgery. Monday was used as the reference category and all variables reported in Table 1 were included in the multivariable adjusted model. For presentational purposes, the hazard ratios and 95% CIs for Saturday/Sunday were omitted from the Figure but are shown in Table 2.

Sensitivity Analyses

We repeated the analyses restricted to patients operated on between 2005 and 2013 to evaluate possible secular trends (Table S2). We also repeated the analyses restricted to patients who underwent elective isolated coronary artery bypass graft to investigate the association between weekday of surgery and survival in a low-risk subset of patients who underwent a single procedure (Table S3). In addition to the main analyses in the imputed data sets, we carried out a complete case analysis (n=61 425) (Table S4). We also applied an alternative missing data strategy in which we assigned missing values an indicator category. All sensitivity analyses gave results that were similar to the main analyses.

Discussion

In this nationwide cohort study, we found no evidence of a clinically important weekday or weekend effect in patents who underwent cardiac surgery in Sweden during a 15-year period. Patients operated on during weekends had increased crude postoperative mortality compared with patients undergoing surgery during weekdays, but this risk increase did not persist when we accounted for the urgency of the procedure. Importantly, addition of other clinical parameters did not affect estimates, indicating that residual confounding should be unlikely and that results are likely to be robust. The difference in loss of life expectancy at 3 years in patients who underwent elective surgery during any weekday compared with Monday was negligible.

Most previous research regarding weekday admission and mortality has focused on acute admissions and the results were contradictory; some studies linked weekend admissions to higher mortality,[21,22] and some did not.[23] Very few studies have investigated the possible weekday effect of surgical procedures on adverse outcomes.[1–3] A study of major nonemergent, noncardiac surgery using the Veterans Affairs' database found that 30-day mortality was increased in patients admitted to non–intensive care unit wards after undergoing surgery on Fridays compared with earlier weekdays,[1] although the observed risk was significantly reduced after adjusting for known patient characteristics. Another study that focused on elective surgical procedures in English hospitals found a higher risk of death for patients who underwent surgical procedures during weekends compared with Mondays.[3] However, this study was based on hospital administrative data without detailed information regarding individual patient characteristics. A recent Swedish population-based cohort study

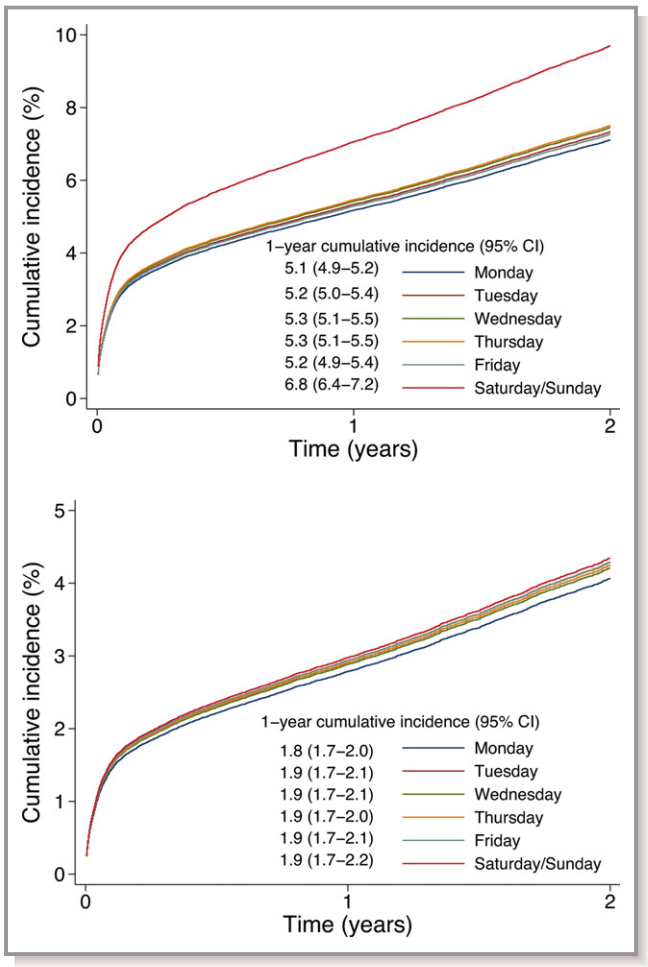

Figure 3. Cumulative mortality according to weekday. Crude (upper panel) and multivariable adjusted (lower panel) cumulative mortality following cardiac surgery in Sweden during 1999 to 2013 according to weekday of surgery.

Table 3. Restricted Mean Survival Time (Days) and Difference in Restricted Mean Survival Time (Days) at 1 and 3 Years Postoperatively in Patients Who Underwent Elective Surgery (n=46 146) According to Weekday of Surgery

	Mean Survival Time, d (95% CI)	Difference in Survival Time vs Monday, d (95% CI)	*P* Value
Follow-up at 1 y			
Monday	355 (354–356)	. . .	. . .
Tuesday	355 (354–356)	−0.5 (−1.8 to 0.8)	0.48
Wednesday	355 (354–356)	−0.5 (−1.9 to 0.8)	0.45
Thursday	354 (353–355)	−1.0 (−2.6 to 0.5)	0.18
Friday	355 (353–357)	0.02 (−2.2 to 2.3)	0.99
Saturday/ Sunday	354 (349–359)	−1.2 (−6.3 to 3.9)	0.65
Follow-up at 3 y			
Monday	1046 (1042–1049)	. . .	. . .
Tuesday	1042 (1038–1045)	−4.3 (−9.3 to 0.8)	0.10
Wednesday	1043 (1039–1047)	−3.2 (−8.4 to 2.0)	0.23
Thursday	1041 (1037–1046)	−4.7 (−10 to 1.0)	0.11
Friday	1042 (1034–1050)	−4.0 (−13 to 4.7)	0.37
Saturday/ Sunday	1042 (1024–1061)	−3.6 (−23 to 15)	0.71

included 1748 patients who underwent elective esophagectomy for esophageal cancer, and investigated whether weekday of surgery influenced long-term all-cause and disease-specific mortality.[2] That study was strengthened by the nationwide design, large study population, complete follow-up, and the detailed adjustment for prognostic factors. The authors found better all-cause and disease-specific 5-year survival in patients who had surgery on Monday or Tuesday compared with those who underwent surgery during Wednesday, Thursday, or Friday.[2] The authors discussed a possible mechanism that might explain their results in this particular setting; surgery for esophageal cancer is a demanding procedure (mean operating time 6.5 hours) and the alertness and surgical precision of the surgeon, and the surgical team, may be impaired later in the week.[2]

The reports showing higher mortality in patients admitted or operated on during weekends have discussed 2 potential explanations. First, it has been speculated that this association was mediated through poorer quality of care during the weekend, possibly because of reduced or less experienced weekend staffing.[1,3] Second, it seems clear that patients undergoing surgery or having acute admissions during weekends were more severely ill compared with patients admitted during weekdays.[4] Thus, it is important that studies investigating a possible weekday or weekend effect are designed to be able to account for patient risk profile. This was recently illustrated in the setting of stroke care. One study reported lower rates of treatments and worse outcomes in patients admitted for stroke during weekends compared with weekdays.[24] However, another study using a specialist clinical database that provided the possibility to adjust for the stroke severity on admission showed no difference in 30-day mortality related to day of admission.[25]

The majority of studies in relation to surgical procedures or acute admissions investigating this topic have been conducted using hospital administrative data without detailed information about patient comorbidity or operative risk.[3–5,24] Therefore, our study extends the findings from previous research because the role of risk factor profile, urgency, and type of procedure could be accounted for in detail through

access to SWEDEHEART and other national Swedish health-data registers.

In Sweden, all patients benefit from universal tax-financed health care, irrespective of employment status and individual financial situation.[15] Insurance status or availability did not influence the indication for surgery. During the study period, cardiac surgery was performed with very similar and stable results in 8 hospitals in Sweden.[26] The staffing levels, working hours, access to diagnostics, and physiotherapy were similar between centers.

In the present study, the significant association between weekday of surgery and mortality found in the unadjusted analyses was largely explained and eliminated by accounting for the urgency of the procedure. The patient characteristics were very similar across weekdays with the exception that urgent surgery was more common during Friday and during the weekend. Moreover, the loss of life expectancy analyses supported the finding of a trivial difference between weekdays after restricting the analyses to patients who underwent elective surgery. Our results were in line with a previous letter to the editor reporting that weekday of surgery was not associated with early mortality following cardiac surgery in England and Wales after risk factor adjustment.[27] Interestingly, in the study by Aylin et al, early mortality in the subset of patients who underwent coronary artery bypass graft was not affected by weekday of surgery.[3]

Study Strengths and Limitations

The strengths of our study included the large study population and the complete and accurate follow-up and survival ascertainment because of the high-quality national Swedish registries, as well as the external validity and generalizability of our findings because of the nationwide complete coverage. Furthermore, we had detailed information regarding patient characteristics, including socioeconomic data, which allowed multivariable adjustment to address confounding. However, there are some important limitations of the study. First, we only had information regarding which weekday a patient underwent surgery, and not the exact time of day. Therefore, we were unable to investigate the association between time of day and outcomes, and also this fact entails a risk for misclassification of exposure because patients assigned to a specific weekday were in fact operated on during the night between 2 weekdays. Second, although we adjusted for a considerable number of established risk factors and risk markers, the possibility remains that residual confounding could have influenced the results. Because this nationwide study was conducted within the Swedish healthcare system, it is unclear whether our findings are valid in other countries where the provision and organization of cardiac surgery may be different.

Conclusions

We found no evidence for a clinically relevant association between weekday of surgery and early or long-term mortality after cardiac surgery. Patients operated on during weekends had increased crude postoperative mortality, but this risk increase was attenuated after accounting for the urgency of the procedure. The difference in loss of life expectancy at 3 years in patients who underwent elective surgery during any weekday compared with Monday was negligible. These data suggest that early risk and long-term prognosis after cardiac surgery are not affected by the day of surgery per se.

Acknowledgments

The authors are grateful to the steering committee of SWEDEHEART for providing data for this study.

Sources of Funding

This study was supported by grants from the Swedish Society of Medicine (Dr Sartipy and Dr Holzmann), Karolinska Institutet Foundations and Funds (Dr Sartipy), the Mats Kleberg Foundation (Dr Sartipy), the Swedish Society for Medical Research (Dr Edgren), the Strategic research program in Epidemiology at Karolinska Institutet (Dr Edgren), and the Swedish Heart-Lung Foundation (Dr Sartipy and Dr Holzmann).

Disclosures

None.

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SUPPLEMENTAL MATERIAL

Table S1.

Myocardial infarction	
ICD 9 codes:	410
ICD 10 codes:	I21 to I21.9
Stroke	
ICD 9 codes:	430 to 438
ICD 10 codes:	I60 to I69.9
Heart failure	
ICD 9 codes:	425, 428
ICD 10 codes:	I50 to I50.9, I42 to I43.9, I25.5, K76.1, I11.0, I13.0, I13.2
Atrial fibrillation	
ICD 9 codes:	427D
ICD 10 codes:	I48 to I48.9
Chronic obstructive pulmonary disease	
ICD 9 codes:	490 to 496
ICD 10 codes:	J44 to J44.9
Hypertension	
ICD 9 codes:	401 to 405
ICD 10 codes:	I10 to I15.9
Hyperlipidemia	
ICD 9 codes:	272
ICD 10 codes:	E78 to E78.9
Peripheral vascular disease	
ICD 9 codes:	440 to 446
ICD 10 codes:	I65 to I65.9, I71 to I71.9, I73.8, I73.9
Percutaneous coronary intervention	
ICD 9 codes:	3080
ICD 10 codes:	FNG00 to FNG06
Alcohol dependency	
ICD 9 codes:	291, 303, 571
ICD 10 codes:	F10 to F10.9, K70 to K70.9
Diabetes mellitus	
ICD 9 codes:	250
ICD 10 codes:	E10 to E14.9
Cancer	
ICD 9 codes:	140 to 208
ICD 10 codes:	C00 to C97.9

Table S2. Sensitivity analysis – recent era (2005-2013).
Event rates and relative risks for all-cause mortality following cardiac surgery in Sweden during 2005 to 2013 according to weekday of surgery.

	Number of deaths/Person-Years	Unadjusted mortality rate per 1000 Person-Years (95% CI)	Crude HR (95% CI)	Multivariable* adjusted HR (95% CI)
0 to 30 days follow-up				
Monday	287/1112	(230-290)	1.00 (ref)	1.00 (ref)
Tuesday	326/1055	(277-345)	1.21 (1.03-1.41)	1.14 (0.97-1.34)
Wednesday	292/979	(266-335)	1.16 (0.99-1.37)	1.03 (0.88-1.22)
Thursday	279/868	(286-362)	1.26 (1.07-1.48)	1.04 (0.88-1.23)
Friday	142/373	(323-448)	1.49 (1.21-1.82)	1.00 (0.81-1.23)
Sat/Sun	198/194	(888-1173)	3.96 (3.30-4.75)	1.42 (1.17-1.73)
30 days to 1 year follow-up				
Monday	313/11754	(24-30)	1.00 (ref)	1.00 (ref)
Tuesday	293/11187	(23-29)	0.99 (0.84-1.16)	0.94 (0.80-1.11)
Wednesday	301/10361	(26-33)	1.10 (0.94-1.29)	1.01 (0.87-1.19)
Thursday	258/9191	(25-32)	1.06 (0.90-1.25)	0.95 (0.80-1.12)
Friday	138/3889	(30-42)	1.33 (1.09-1.63)	1.14 (0.93-1.41)
Sat/Sun	67/2016	(26-42)	1.24 (0.95-1.62)	0.88 (0.66-1.16)
1 to 10 years follow-up				
Monday	1342/48023	(27-30)	1.00 (ref)	1.00 (ref)
Tuesday	1373/45538	(29-32)	1.08 (1.00-1.17)	1.06 (0.99-1.15)
Wednesday	1330/43186	(29-33)	1.10 (1.02-1.18)	1.06 (0.98-1.14)
Thursday	1141/38224	(28-32)	1.07 (0.99-1.16)	1.05 (0.97-1.13)
Friday	517/15319	(31-37)	1.22 (1.1-1.35)	1.23 (1.11-1.37)
Sat/Sun	246/8537	(25-33)	1.03 (0.9-1.18)	1.03 (0.89-1.20)

*Model included all variables reported in Table 1.
Ref = reference category, HR = hazard ratio, CI = confidence interval.

Table S3. Sensitivity analysis – elective isolated CABG.
Event rates and relative risks for all-cause mortality following elective isolated CABG in Sweden during 1999 to 2013 according to weekday of surgery.

	Number of deaths/Person-Years	Unadjusted mortality rate per 1000 Person-Years (95% CI)	Crude HR (95% CI)	Multivariable* adjusted HR (95% CI)
0 to 30 days follow-up				
Monday	64/520	(96-157)	1.00 (ref)	1.00 (ref)
Tuesday	63/486	(101-166)	1.05 (0.74-1.48)	1.01 (0.71-1.43)
Wednesday	48/414	(87-154)	0.93 (0.64-1.35)	0.90 (0.62-1.32)
Thursday	41/314	(96-178)	1.05 (0.71-1.56)	1.02 (0.68-1.51)
Friday	21/121	(113-266)	1.36 (0.82-2.24)	1.49 (0.90-2.46)
Sat/Sun	2/28	(18-290)	0.64 (0.15-2.64)	0.70 (0.17-2.90)
30 days to 1 year follow-up				
Monday	93/5633	(14-20)	1.00 (ref)	1.00 (ref)
Tuesday	105/5289	(16-24)	1.20 (0.91-1.59)	1.13 (0.85-1.50)
Wednesday	78/4501	(14-22)	1.05 (0.77-1.42)	0.99 (0.73-1.34)
Thursday	64/3410	(15-24)	1.13 (0.82-1.56)	1.07 (0.77-1.48)
Friday	27/1305	(14-30)	1.30 (0.84-2.01)	1.33 (0.86-2.06)
Sat/Sun	5/303	(7-40)	1.14 (0.46-2.83)	1.21 (0.49-3.02)
1 to 15 years follow-up				
Monday	936/32585	(27-31)	1.00 (ref)	1.00 (ref)
Tuesday	983/31129	(30-34)	1.09 (1.00-1.19)	1.08 (0.99-1.18)
Wednesday	792/27042	(27-31)	1.00 (0.91-1.10)	0.99 (0.90-1.09)
Thursday	609/20700	(27-32)	1.01 (0.91-1.12)	1.02 (0.92-1.13)
Friday	235/7808	(27-34)	1.06 (0.92-1.23)	1.14 (0.99-1.32)
Sat/Sun	40/1830	(16-30)	0.82 (0.59-1.13)	0.92 (0.67-1.27)

*Model included all variables reported in Table 1.
Ref = reference category, HR = hazard ratio, CI = confidence interval.

Table S4. Sensitivity analysis – complete case analysis
Event rates and relative risks for all-cause mortality following cardiac surgery in Sweden during 1999 to 2013 according to weekday of surgery.

	Number of deaths/Person-Years	Unadjusted mortality rate per 1000 Person-Years (95% CI)	Crude HR (95% CI)	Multivariable* adjusted HR (95% CI)
0 to 30 days follow-up				
Monday	593/2038	291 (268-315)	1.00 (ref)	1.00 (ref)
Tuesday	637/1974	323 (299-349)	1.11 (0.99-1.24)	1.10 (0.93-1.30)
Wednesday	598/1853	323 (298-350)	1.11 (0.99-1.25)	1.07 (0.90-1.27)
Thursday	567/1626	349 (321-379)	1.21 (1.08-1.36)	1.09 (0.91-1.30)
Friday	289/744	389 (346-436)	1.36 (1.18-1.57)	1.04 (0.83-1.30)
Sat/Sun	355/337	1053 (949-1169)	3.62 (3.17-4.14)	1.23 (0.98-1.55)
30 days to 1 year follow-up				
Monday	559/21885	26 (24-28)	1.00 (ref)	1.00 (ref)
Tuesday	558/21229	26 (24-29)	1.03 (0.92-1.16)	1.01 (0.86-1.19)
Wednesday	542/19922	27 (25-30)	1.07 (0.95-1.20)	1.05 (0.89-1.24)
Thursday	492/17452	28 (26-31)	1.11 (0.98-1.25)	0.99 (0.83-1.18)
Friday	257/7917	33 (29-37)	1.30 (1.12-1.51)	1.07 (0.86-1.34)
Sat/Sun	130/3538	37 (31-44)	1.42 (1.17-1.72)	0.96 (0.71-1.29)
1 to 15 years follow-up				
Monday	5628/149442	38 (37-39)	1.00 (ref)	1.00 (ref)
Tuesday	5633/146465	39 (38-40)	1.02 (0.98-1.06)	1.06 (1.00-1.13)
Wednesday	5374/138946	39 (38-40)	1.02 (0.99-1.06)	1.03 (0.97-1.10)
Thursday	4635/121034	38 (37-39)	1.01 (0.97-1.05)	1.06 (1.00-1.13)
Friday	2043/57018	36 (34-37)	0.94 (0.89-0.99)	1.07 (0.98-1.17)
Sat/Sun	908/23476	39 (36-41)	1.03 (0.96-1.10)	1.09 (0.96-1.23)

*Model included all variables reported in Table 1, (n=61,425).
Ref = reference category, HR = hazard ratio, CI = confidence interval.