Impact of Atrial Fibrillation on 30-Day Readmissions Following Colorectal Cancer Surgery: Insights from the Nationwide Readmissions Database

RCOP NRD A11

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## Preamble:

* **Reference Studies:**
  + [Walsh et al., 2004](https://pmc.ncbi.nlm.nih.gov/articles/PMC538254/)
  + [Patel et al., 2021](https://doi.org/10.1093/eurheartj/ehab724.0595)
  + [Lee et al., 2020](https://onlinelibrary.wiley.com/doi/full/10.1111/codi.15314)
* **Study Objective:**
* To evaluate the risk of 30-day all-cause hospital readmission in patients undergoing colorectal cancer surgery (CRCS), comparing those with Atrial fibrillation (AF) and those without AF . The study also characterizes index hospitalization outcomes and readmission stay features. A secondary objective is to identify risk factors associated with 30-day readmission in this high-risk population using a logistic regression model.
* **Data Source:**
* This retrospective cohort study used data from the 2016–2017 Nationwide Readmissions Database (NRD), developed by the Healthcare Cost and Utilization Project (HCUP). The NRD is a nationally representative, all-payer database of U.S. hospitalizations that allows linkage of patients across hospital stays within a calendar year. Survey weights, stratification, and clustering variables support complex sampling design for national estimates.
* **Cohort Definition:**
* Index admissions were selected based on the following inclusion criteria:
  + Adults aged ≥18 years
  + Principal diagnosis of CRCS , identified using ICD-10-CM codes for CRCS (isCRCS pattern, including 0DTF0ZZ, 0DTF4ZZ, 0DTG0ZZ, 0DTG4ZZ, 0DTH0ZZ, 0DTH4ZZ, 0DTJ0ZZ, 0DTJ4ZZ, 0DTK0ZZ, 0DTK4ZZ, 0DTT0ZZ, 0DTT4ZZ)
  + Whether patients had AF or not:
  + AF: e.g., I48.0, I48.1, I48.2, I48.3, I48.4, I48.91, I48.92
  + Non-elective admission
  + Index discharge by the end of November to allow for a complete 30-day follow-up period
  + Complete data on LOS and NRD\_DAYSTOEVENT, required to compute discharge dates
* Readmissions were defined as:
  + Any non-trauma hospitalization within 30 days of discharge
* **Outcomes of Interest:**
  + Primary Outcome:
    - 30-day all-cause readmission (Yes/No), flagged using NRD linkage variables
  + Secondary Outcomes (index admission):
    - In-hospital mortality (DIED)
    - Length of stay (LOS, continuous in days and also categorized as ≤4 vs >4 days)
    - Total hospitalization charges (TOTCHG), inflation-adjusted to 2017 USD
    - Non-home discharge
  + Outcomes during readmission:
    - In-hospital mortality
    - Length of stay (LOS, in days)
    - Total hospitalization charges (inflation-adjusted to 2017 USD)
* **Outcome Definitions:**
  + Readmission:
    - Defined using HCUP NRD’s methodology. Readmissions were identified only among patients with qualifying index events.
    - Trauma-related hospitalizations were excluded only from the readmission pool to avoid unrelated admissions.
  + Mortality:
    - In-hospital death recorded during index or readmission (DIED = 1)
  + LOS:
    - Reported in days; modeled as count outcome
  + Charge:
    - Derived from HCUP’s TOTCHG variable and adjusted to 2017 dollars using Consumer Price Index (CPI) data
  + Non-Home Discharge:
    - Defined as any disposition other than home/self-care, specifically:
      * Transfer to another short-term hospital
      * Transfer to skilled nursing facility (SNF), intermediate, or other facility
      * Left against medical advice
      * Died in hospital
      * Alive, destination unknown
* **Covariates and Variable Construction:**
  + Demographic & Socioeconomic Factors:
    - Age (continuous)
    - Sex (FEMALE; ref = Male)
    - Primary expected payer (Insurance; Medicare, Medicaid, Private, Other)
    - ZIP-based median income quartile (ZIPINC\_QRTL)
    - Weekend admission (AWEEKEND)
  + Clinical Comorbidities:
    - Elixhauser comorbidity variables:
      * Diabetes
      * Peripheral vascular disease
      * Chronic pulmonary disease
      * Hypertension
      * Congestive heart failure
      * Alcohol abuse
      * Obesity
      * Anemia
      * Renal failure
      * Liver disease
  + Additional clinical risk factors (non-Elixhauser)
    - Smoking
    - Previous stroke or transient ischemic attack
    - Coagulopathy
    - Acute myocardial infarction
  + Hospital Characteristics:
    - Hospital bed size (Small, Medium, Large)
    - Urban/rural teaching status (Metropolitan, teaching vs non-teaching, etc.)
  + Disposition and Severity:
    - Non-home discharge (e.g., SNF, hospice, other facilities, or death)
    - Length of stay (categorized as above)
* **Statistical Methods:**
  + Survey Design and Weighting:
    - All analyses accounted for NRD’s complex survey design using weights (DISCWT), strata (NRD\_STRATUM), and clustering (HOSP\_NRD). Survey-adjusted methods were implemented via survey and srvyr packages.
  + Descriptive Analyses:
    - Baseline characteristics were stratified based on the presence or absence of AF in patients undergoing CRCS during index admissions.
    - P-values from design-based statistical tests (Rao–Scott adjusted chi-square for categorical variables; design-based Kruskal–Wallis test for continuous variables).
  + Multivariable Analysis:
    - A survey-weighted logistic regression modeled predictors of 30-day readmission.
    - The model included demographic, clinical, hospital-level, and index-stay factors.
    - Reference levels were explicitly set (e.g., Male, LOS ≤4 days).
    - Results were exponentiated to yield odds ratios (ORs) with 95% confidence intervals.
  + Readmission Characteristics:
    - A sub-analysis among patients with 30-day readmissions summarized readmission hospitalization characteristics descriptively using weighted survey statistics.
* **Software:** All analyses were conducted in R Statistical Language (Version 4.5.0; R Foundation for Statistical Computing, Vienna, Austria).

## Descriptive Analyses:

### Baseline Characteristics

| **Characteristic** | **Overall** N = 323,326*1* | **Colorectal cancer surgery without Atrial Fibrillation** N = 298,370*1* | **Colorectal cancer surgery with Atrial Fibrillation** N = 24,955*1* | **p-value***2* |
| --- | --- | --- | --- | --- |
| Age (years) | 51 (19) | 49 (19) | 74 (12) | <0.001 |
| Sex |  |  |  | <0.001 |
| Male | 158,817 (49%) | 145,552 (49%) | 13,265 (53%) |  |
| Female | 164,508 (51%) | 152,819 (51%) | 11,690 (47%) |  |
| Primary Expected Payer |  |  |  | <0.001 |
| Private | 137,912 (43%) | 134,428 (45%) | 3,484 (14%) |  |
| Medicaid | 54,395 (17%) | 53,346 (18%) | 1,049 (4.2%) |  |
| Medicare | 96,561 (30%) | 76,978 (26%) | 19,582 (79%) |  |
| Other | 34,034 (11%) | 33,212 (11%) | 822 (3.3%) |  |
| Median Household Income Quartile |  |  |  | <0.001 |
| 0-25th percentile | 87,997 (28%) | 81,679 (28%) | 6,318 (26%) |  |
| 26th to 50th percentile | 84,527 (26%) | 77,504 (26%) | 7,024 (29%) |  |
| 51st to 75th percentile | 79,789 (25%) | 73,555 (25%) | 6,233 (25%) |  |
| 76th to 100th percentile | 66,704 (21%) | 61,683 (21%) | 5,021 (20%) |  |
| Admission Day |  |  |  | 0.13 |
| Monday-Friday | 241,259 (75%) | 222,488 (75%) | 18,770 (75%) |  |
| Saturday-Sunday | 82,067 (25%) | 75,882 (25%) | 6,185 (25%) |  |
| Hospital Bed Size |  |  |  | 0.070 |
| Small | 55,858 (17%) | 51,765 (17%) | 4,094 (16%) |  |
| Large | 173,237 (54%) | 159,559 (53%) | 13,678 (55%) |  |
| Medium | 94,230 (29%) | 87,046 (29%) | 7,184 (29%) |  |
| Hospital Location and Teaching Status |  |  |  | 0.7 |
| Metropolitan, non-teaching | 94,420 (29%) | 87,231 (29%) | 7,190 (29%) |  |
| Metropolitan, teaching | 200,485 (62%) | 184,967 (62%) | 15,518 (62%) |  |
| Non-metropolitan | 28,420 (8.8%) | 26,173 (8.8%) | 2,247 (9.0%) |  |
| Anemia | 24,179 (7.5%) | 19,671 (6.6%) | 4,508 (18%) | <0.001 |
| Congestive Heart Failure | 19,792 (6.1%) | 11,271 (3.8%) | 8,521 (34%) | <0.001 |
| Coagulopathy | 5,320 (1.6%) | 3,856 (1.3%) | 1,464 (5.9%) | <0.001 |
| Chronic Kidney Disease | 21,546 (6.7%) | 15,639 (5.2%) | 5,907 (24%) | <0.001 |
| Chronic Pulmonary Disease | 41,902 (13%) | 35,234 (12%) | 6,668 (27%) | <0.001 |
| Liver disease | 13,343 (4.1%) | 11,537 (3.9%) | 1,806 (7.2%) | <0.001 |
| Diabetes | 45,097 (14%) | 37,829 (13%) | 7,268 (29%) | <0.001 |
| Smoking | 43,696 (14%) | 41,480 (14%) | 2,216 (8.9%) | <0.001 |
| Peripheral Vascular Disease | 17,483 (5.4%) | 12,647 (4.2%) | 4,836 (19%) | <0.001 |
| Hypertension | 101,874 (32%) | 88,008 (29%) | 13,867 (56%) | <0.001 |
| Prior Stroke or TIA | 10,654 (3.3%) | 7,857 (2.6%) | 2,797 (11%) | <0.001 |
| Alcohol Abuse | 8,233 (2.5%) | 7,304 (2.4%) | 929 (3.7%) | <0.001 |
| Acute Myocardial Infarction | 2,646 (0.8%) | 1,741 (0.6%) | 905 (3.6%) | <0.001 |
| Obesity | 45,193 (14%) | 40,599 (14%) | 4,594 (18%) | <0.001 |
| *1*Mean (SD); n (%) | | | | |
| *2*Design-based KruskalWallis test; Pearson's X^2: Rao & Scott adjustment | | | | |

### Outcomes of Index Hospitalization

| **Characteristic** | **Overall** N = 323,326*1* | **Colorectal cancer surgery without Atrial Fibrillation** N = 298,370*1* | **Colorectal cancer surgery with Atrial Fibrillation** N = 24,955*1* | **p-value***2* |
| --- | --- | --- | --- | --- |
| 30-Day Readmission | 18,082 (5.6%) | 15,537 (5.2%) | 2,545 (10%) | <0.001 |
| In-Hospital Mortality | 7,966 (2.5%) | 5,176 (1.7%) | 2,790 (11%) | <0.001 |
| Length of Stay (days) | 3 (2, 8) | 3 (1, 7) | 10 (5, 17) | <0.001 |
| Inflation-Adjusted Total Charges ($) | 51,417 (32,490, 91,430) | 49,143 (31,611, 84,670) | 109,997 (60,639, 205,798) | <0.001 |
| Discharged to Non-Home Setting | 38,082 (12%) | 26,891 (9.0%) | 11,192 (45%) | <0.001 |
| *1*n (%); Median (Q1, Q3) | | | | |
| *2*Pearson's X^2: Rao & Scott adjustment; Design-based KruskalWallis test | | | | |

## Multivariable Analyses

### Risk Factors for 30-Day Readmission

| **Characteristic** | **OR** | **95% CI** | **p-value** |
| --- | --- | --- | --- |
| Colorectal cancer surgery categories |  |  |  |
| Colorectal cancer surgery with Atrial Fibrillation | — | — |  |
| Colorectal cancer surgery without Atrial Fibrillation | 0.93 | 0.87, 1.00 | 0.063 |
| Age (years) | 1.01 | 1.01, 1.02 | <0.001 |
| Sex |  |  |  |
| Female | — | — |  |
| Male | 0.97 | 0.93, 1.02 | 0.2 |
| Primary Expected Payer |  |  |  |
| Medicaid | — | — |  |
| Medicare | 0.85 | 0.78, 0.94 | 0.001 |
| Other | 1.09 | 0.98, 1.22 | 0.10 |
| Private | 0.90 | 0.84, 0.97 | 0.008 |
| Median Household Income Quartile |  |  |  |
| 0-25th percentile | — | — |  |
| 26th to 50th percentile | 0.98 | 0.91, 1.04 | 0.5 |
| 51st to 75th percentile | 0.90 | 0.84, 0.96 | <0.001 |
| 76th to 100th percentile | 0.83 | 0.77, 0.89 | <0.001 |
| Admission Day |  |  |  |
| Monday-Friday | — | — |  |
| Saturday-Sunday | 1.53 | 1.45, 1.62 | <0.001 |
| Hospital Bed Size |  |  |  |
| Large | — | — |  |
| Medium | 1.06 | 0.99, 1.13 | 0.075 |
| Small | 1.05 | 0.98, 1.13 | 0.2 |
| Hospital Location and Teaching Status |  |  |  |
| Metropolitan, non-teaching | — | — |  |
| Metropolitan, teaching | 0.91 | 0.86, 0.96 | 0.001 |
| Non-metropolitan | 0.76 | 0.68, 0.84 | <0.001 |
| Non\_Home\_Discharge |  |  |  |
| No | — | — |  |
| Yes | 1.78 | 1.67, 1.90 | <0.001 |
| Anemia |  |  |  |
| No | — | — |  |
| Yes | 1.41 | 1.31, 1.51 | <0.001 |
| Congestive Heart Failure |  |  |  |
| No | — | — |  |
| Yes | 1.31 | 1.20, 1.42 | <0.001 |
| Coagulopathy |  |  |  |
| No | — | — |  |
| Yes | 1.05 | 0.89, 1.23 | 0.5 |
| Chronic Kidney Disease |  |  |  |
| No | — | — |  |
| Yes | 1.41 | 1.30, 1.54 | <0.001 |
| Chronic Pulmonary Disease |  |  |  |
| No | — | — |  |
| Yes | 1.15 | 1.08, 1.22 | <0.001 |
| Liver disease |  |  |  |
| No | — | — |  |
| Yes | 1.18 | 1.07, 1.31 | <0.001 |
| Diabetes |  |  |  |
| No | — | — |  |
| Yes | 1.23 | 1.16, 1.31 | <0.001 |
| Smoking |  |  |  |
| No | — | — |  |
| Yes | 1.42 | 1.33, 1.52 | <0.001 |
| Peripheral Vascular Disease |  |  |  |
| No | — | — |  |
| Yes | 1.35 | 1.25, 1.47 | <0.001 |
| Hypertension |  |  |  |
| No | — | — |  |
| Yes | 1.13 | 1.06, 1.20 | <0.001 |
| Prior Stroke or TIA |  |  |  |
| No | — | — |  |
| Yes | 1.09 | 0.99, 1.20 | 0.089 |
| Alcohol Abuse |  |  |  |
| No | — | — |  |
| Yes | 1.37 | 1.21, 1.57 | <0.001 |
| Acute Myocardial Infarction |  |  |  |
| No | — | — |  |
| Yes | 1.13 | 0.94, 1.36 | 0.2 |
| Obesity |  |  |  |
| No | — | — |  |
| Yes | 0.93 | 0.87, 0.99 | 0.025 |
| Abbreviations: CI = Confidence Interval, OR = Odds Ratio | | | |

used (Mb) gc trigger (Mb) max used (Mb)  
Ncells 64118432 3424.3 105219158 5619.4 105219158 5619.4  
Vcells 1789002821 13649.1 2888693093 22039.0 2237241759 17068.9

### LOS and Cost by Readmission Status:

Readmission Hospitalizations resulted in

1. Median Length of Stay (IQR), days: 4 (IQR: 2–7)
2. Median Total Charges (IQR): $31,050 (IQR: $17,555–$57,990)

### In-Hospital Mortality Among Readmitted Patients

Readmission hospitalizations resulted in:

1. Deaths (n): 559
2. Death Rate (%): 3.1%
3. Death Rate (95% CI): 2.71% to 3.49%