Association Between Obesity and 30-Day Readmissions Following Atrial Fibrillation Ablation

RCOP NRD A9

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## Preamble:

* **Reference Studies:**
  + [Ullah et al., 2023](https://doi.org/10.1093/ehjopen/oead026)
  + [Wu et al., 2022](https://doi.org/10.1111/pace.14543)
  + [Yeo et al., 2019](https://doi.org/10.1001/jamanetworkopen.2019.12208)
* **Study Objective:**
* To evaluate the association between obesity and 30-day all-cause hospital readmission following catheter ablation (CA) for atrial fibrillation (AF) among adults in the United States. Secondary objectives included:
  + Comparing demographic, clinical, and hospital-level characteristics by obesity category
  + Assessing differences in index hospitalization outcomes (mortality, LOS, charges, disposition) by obesity
  + Characterizing in-hospital outcomes and resource utilization among readmitted patients
  + Identifying independent predictors of 30-day readmission using survey-weighted Cox regression
* **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 hospitalizations were defined using the following criteria:
  + Adults aged ≥18 years
  + Principal diagnosis of atrial fibrillation, identified using ICD-10-CM codes:
    - I480, I481, I4811, I4819, I482, I4820, I4821, I4891
  + Underwent catheter ablation during the same hospitalization, identified using ICD-10-PCS procedure codes:
    - 02583ZZ, 02563ZZ, 02573ZZ, 025T3ZZ, 025S3ZZ
  + 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
* **Exposure Definition: Obesity**
* Obesity was defined using secondary diagnosis fields containing ICD-10-CM codes:
  + E6601, E6609, E661, E662, E668, E66811–E66813, E6689, E669
  + Z6830–Z6839, Z6841–Z6845
* Patients were classified into “Obese” and “Non-Obese” based on the presence or absence of these codes.
* **Outcomes of Interest:**
  + Primary Outcome:
    - All-cause 30-day readmission (Yes/No), flagged using NRD linkage variables
  + Secondary Outcomes (index admission):
    - In-hospital mortality (DIED)
    - Length of stay (LOS, in days)
    - Total hospitalization charges (TOTCHG), inflation-adjusted to 2017 USD
    - Non-home discharge
  + Readmission Characteristics:
    - 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)
    - Income quartile based on ZIP code (ZIPINC\_QRTL)
    - Weekend admission (AWEEKEND)
    - Admission type (ELECTIVE: Elective vs. Non-elective)
  + Comorbidities and Clinical Covariates
    - Diabetes
    - Renal failure
    - Congestive heart failure (CHF)
    - Chronic pulmonary disease
    - Depression
    - Liver disease
    - Hypertension
    - Myocardial infarction (MI)
    - History of stroke or TIA
  + 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
* **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 summarized across obese vs. non-obese groups using survey-weighted means/proportions.
    - P-values from design-based statistical tests (Rao–Scott adjusted chi-square for categorical variables; design-based Kruskal–Wallis test for continuous variables).
  + Multivariable Regression:
    - A survey-weighted Cox proportional hazards model was used to evaluate the association between obesity and 30-day readmission.
    - The model included demographic, clinical, hospital-level, and index-stay factors.
    - Hazard ratios (HRs) with 95% confidence intervals (CIs) were reported
  + 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 = 34,186*1* | **Non-Obese** N = 25,974*1* | **Obese** N = 8,212*1* | **p-value***2* |
| --- | --- | --- | --- | --- |
| Age (years) | 68 (12) | 69 (12) | 64 (11) | <0.001 |
| Sex |  |  |  | 0.8 |
| Male | 19,356 (57%) | 14,722 (57%) | 4,634 (56%) |  |
| Female | 14,830 (43%) | 11,253 (43%) | 3,578 (44%) |  |
| Primary Expected Payer |  |  |  | <0.001 |
| Private | 9,911 (29%) | 6,960 (27%) | 2,951 (36%) |  |
| Medicaid | 1,636 (4.8%) | 1,120 (4.3%) | 516 (6.3%) |  |
| Medicare | 21,555 (63%) | 17,103 (66%) | 4,452 (54%) |  |
| Other | 1,071 (3.1%) | 781 (3.0%) | 291 (3.5%) |  |
| Median Household Income Quartile |  |  |  | <0.001 |
| 0-25th percentile | 7,952 (24%) | 5,903 (23%) | 2,049 (25%) |  |
| 26th to 50th percentile | 8,686 (26%) | 6,523 (26%) | 2,163 (27%) |  |
| 51st to 75th percentile | 8,463 (25%) | 6,356 (25%) | 2,107 (26%) |  |
| 76th to 100th percentile | 8,585 (25%) | 6,780 (27%) | 1,805 (22%) |  |
| Admission Day (Weekend vs Weekday) |  |  |  | 0.3 |
| Monday-Friday | 30,647 (90%) | 23,251 (90%) | 7,396 (90%) |  |
| Saturday-Sunday | 3,539 (10%) | 2,723 (10%) | 816 (9.9%) |  |
| Admission Type (Elective vs Non-Elective) |  |  |  | 0.004 |
| Elective | 17,844 (52%) | 13,333 (52%) | 4,512 (55%) |  |
| Non-elective | 16,167 (48%) | 12,509 (48%) | 3,658 (45%) |  |
| Hospital Bed Size |  |  |  | 0.5 |
| Small | 1,755 (5.1%) | 1,296 (5.0%) | 459 (5.6%) |  |
| Large | 23,058 (67%) | 17,509 (67%) | 5,549 (68%) |  |
| Medium | 9,374 (27%) | 7,170 (28%) | 2,204 (27%) |  |
| Hospital Location and Teaching Status |  |  |  | 0.3 |
| Metropolitan, non-teaching | 4,860 (14%) | 3,767 (15%) | 1,092 (13%) |  |
| Metropolitan, teaching | 28,536 (83%) | 21,573 (83%) | 6,963 (85%) |  |
| Non-metropolitan | 791 (2.3%) | 634 (2.4%) | 156 (1.9%) |  |
| Diabetes Mellitus | 8,713 (25%) | 5,545 (21%) | 3,167 (39%) | <0.001 |
| Renal Failure | 5,571 (16%) | 4,149 (16%) | 1,421 (17%) | 0.057 |
| Congestive Heart Failure | 14,914 (44%) | 10,841 (42%) | 4,073 (50%) | <0.001 |
| Chronic Pulmonary Disease | 7,963 (23%) | 5,563 (21%) | 2,400 (29%) | <0.001 |
| Depression or Anxiety | 2,854 (8.3%) | 1,924 (7.4%) | 930 (11%) | <0.001 |
| Chronic Liver Disease | 765 (2.2%) | 536 (2.1%) | 228 (2.8%) | 0.013 |
| Hypertension | 25,842 (76%) | 18,872 (73%) | 6,970 (85%) | <0.001 |
| Previous Stroke or TIA | 3,184 (9.3%) | 2,545 (9.8%) | 640 (7.8%) | <0.001 |
| Myocardial Infarction | 3,005 (8.8%) | 2,249 (8.7%) | 757 (9.2%) | 0.3 |
| *1*Mean (SD); n (%) | | | | |
| *2*Design-based KruskalWallis test; Pearson's X^2: Rao & Scott adjustment | | | | |

### Outcomes of Index Hospitalizations

| **Characteristic** | **Overall** N = 34,186*1* | **Non-Obese** N = 25,974*1* | **Obese** N = 8,212*1* | **p-value***2* |
| --- | --- | --- | --- | --- |
| 30-Day Readmission | 3,327 (9.7%) | 2,467 (9.5%) | 860 (10%) | 0.11 |
| In-Hospital Mortality | 176 (0.5%) | 146 (0.6%) | 30 (0.4%) | 0.14 |
| Length of Stay (days) | 3.0 (1.0, 5.0) | 3.0 (1.0, 5.0) | 3.0 (2.0, 5.0) | <0.001 |
| Inflation-Adjusted Total Charges ($) | 129,344 (87,201, 186,864) | 126,753 (85,056, 183,902) | 136,856 (93,526, 196,268) | <0.001 |
| Discharged to Non-Home Setting | 2,341 (6.8%) | 1,847 (7.1%) | 494 (6.0%) | 0.019 |
| *1*n (%); Median (Q1, Q3) | | | | |
| *2*Pearson's X^2: Rao & Scott adjustment; Design-based KruskalWallis test | | | | |

## Readmission Hospitalization Characteristics

### In-Hospital Mortality Among Readmitted Patients

Readmission hospitalizations resulted in:

1. Deaths (n): 111
2. Death Rate (%): 3.36%
3. Death Rate (95% CI): 2.44% to 4.28%

### Resource Utilization During Readmission

Readmission hospitalizations resulted in:

1. Median Length of Stay (IQR), days: 3 (IQR: 2–5)
2. Median Total Charges (IQR): $30,381 (IQR: $16,703–$58,019)

## Multivariable Analyses

### Multivariable Predictors of 30-Day Readmission

Stratified 1 - level Cluster Sampling design (with replacement)  
With (671) clusters.  
subset(nrd\_design, IndexEvent == 1)  
Sampling variables:  
 - ids: HOSP\_NRD   
 - strata: NRD\_STRATUM   
 - weights: DISCWT

| **Characteristic** | **HR** | **95% CI** | **p-value** |
| --- | --- | --- | --- |
| Obesity Categories |  |  |  |
| Non-Obese | — | — |  |
| Obese | 0.94 | 0.84, 1.05 | 0.3 |
| Age (years) | 1.00 | 0.99, 1.01 | >0.9 |
| Sex |  |  |  |
| Male | — | — |  |
| Female | 0.97 | 0.87, 1.08 | 0.6 |
| Primary Expected Payer |  |  |  |
| Private | — | — |  |
| Medicaid | 1.01 | 0.79, 1.30 | >0.9 |
| Medicare | 1.03 | 0.88, 1.20 | 0.7 |
| Other | 0.93 | 0.66, 1.30 | 0.7 |
| Median Household Income Quartile |  |  |  |
| 0-25th percentile | — | — |  |
| 26th to 50th percentile | 0.99 | 0.86, 1.14 | >0.9 |
| 51st to 75th percentile | 1.14 | 0.98, 1.33 | 0.088 |
| 76th to 100th percentile | 1.16 | 1.01, 1.34 | 0.032 |
| Admission Day (Weekend vs Weekday) |  |  |  |
| Monday-Friday | — | — |  |
| Saturday-Sunday | 1.05 | 0.93, 1.19 | 0.4 |
| Admission Type (Elective vs Non-Elective) |  |  |  |
| Elective | — | — |  |
| Non-elective | 0.95 | 0.85, 1.06 | 0.3 |
| Hospital Bed Size |  |  |  |
| Small | — | — |  |
| Large | 1.24 | 0.95, 1.61 | 0.12 |
| Medium | 1.17 | 0.89, 1.55 | 0.3 |
| Hospital Location and Teaching Status |  |  |  |
| Metropolitan, non-teaching | — | — |  |
| Metropolitan, teaching | 0.86 | 0.74, 1.00 | 0.058 |
| Non-metropolitan | 0.89 | 0.65, 1.21 | 0.4 |
| Diabetes Mellitus |  |  |  |
| No | — | — |  |
| Yes | 1.02 | 0.92, 1.14 | 0.7 |
| Renal Failure |  |  |  |
| No | — | — |  |
| Yes | 1.02 | 0.90, 1.15 | 0.8 |
| Congestive Heart Failure |  |  |  |
| No | — | — |  |
| Yes | 0.93 | 0.83, 1.04 | 0.2 |
| Chronic Pulmonary Disease |  |  |  |
| No | — | — |  |
| Yes | 1.04 | 0.93, 1.17 | 0.5 |
| Depression or Anxiety |  |  |  |
| No | — | — |  |
| Yes | 1.07 | 0.90, 1.27 | 0.4 |
| Liver Disease |  |  |  |
| No | — | — |  |
| Yes | 1.39 | 1.01, 1.90 | 0.044 |
| Hypertension |  |  |  |
| No | — | — |  |
| Yes | 1.00 | 0.88, 1.14 | >0.9 |
| Previous Stroke or TIA |  |  |  |
| No | — | — |  |
| Yes | 0.93 | 0.79, 1.08 | 0.3 |
| Myocardial Infarction |  |  |  |
| No | — | — |  |
| Yes | 0.93 | 0.80, 1.09 | 0.4 |
| Length of Stay (days) | 1.00 | 0.99, 1.01 | >0.9 |
| Discharged to Non-Home Setting |  |  |  |
| No | — | — |  |
| Yes | 0.83 | 0.70, 0.99 | 0.034 |
| Abbreviations: CI = Confidence Interval, HR = Hazard Ratio | | | |