In-Hospital Outcomes and Complications of Leadless Versus Traditional Transvenous Pacemaker Implantation in Patients with Chronic Kidney Disease

Analysis for RCOP NIS Cardio5

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## Preamble:

* **Reference Papers:**
  + [Alhuarrat et al. 2023](https://academic.oup.com/europace/article/25/9/euad269/7274340)
  + [Khan et al. 2024](https://www.heartrhythmjournal.com/article/S1547-5271(24)02311-7/fulltext)
  + [Salman et al. 2025](https://doi.org/10.1097/MCA.0000000000001479)
* **Study Objective**: To compare in-hospital outcomes and complications between Leadless Pacemakers and Traditional Transvenous (TV-VVI) Pacemakers among patients with Chronic Kidney Disease (CKD) undergoing pacemaker implantation in U.S. hospitals from 2018 to 2020, adjusting for demographic, socioeconomic, clinical (including CKD stage), and hospital-related factors.
* **Data Source**: Cross-sectional analysis using the National Inpatient Sample (NIS) database from 2018 to 2020, a representative sample of all-payer inpatient hospitalizations in the U.S.
* **Patient Selection**: Included all inpatient admissions for patients 18 years or older with a diagnosis of Chronic Kidney Disease (CKD), identified using ICD-10 diagnosis codes. From this cohort, patients who underwent implantation of either a Leadless Pacemaker or a Traditional Transvenous (TV-VVI) Pacemaker, identified using ICD-10-PCS procedure codes, were included. Patients were then categorized into two groups based on the type of pacemaker received: Leadless Pacemaker or Traditional Transvenous Pacemaker.
* **Outcomes of Interest:**
  + In-hospital Mortality
  + Length of Stay (days)
  + Inflation-adjusted Total Charge ($) [adjusted to 2020 dollars, using CPI data by the U.S. Bureau of Labor Statistics]
  + Acute Kidney Injury (AKI)
  + Any Complication (including vascular, pericardial, pneumothorax, infectious, or device-related complications)
* **Statistical Analysis**: Univariable and multivariable analyses were conducted to evaluate the association between pacemaker type (Leadless vs. Traditional Transvenous) and inpatient outcomes within the CKD patient cohort:
  + **Univariable Analysis:**
    - Continuous variables: Design-based Kruskal-Wallis test.
    - Categorical variables: Pearson’s X² test with Rao & Scott adjustment to account for survey design.
  + **Multivariable Analysis:**
    - Logistic regression for binary outcomes (e.g., in-hospital mortality, AKI).
    - Linear regression for continuous outcomes (e.g., length of stay, total charges).
  + **Adjustments:** Models controlled for the following covariates:
    - **Demographics and Socioeconomic Factors**: Age, Sex, Race, Residential income, Expected primary payer.
    - **Clinical Factors:** Charlson comorbidity index, Admission Type, Chronic Kidney Disease Stage, Hypertension, Diabetes Mellitus, Obesity, Chronic Pulmonary Disease, Liver Disease, Peripheral Vascular Disease, Congestive Heart Failure, Myocardial Infarction.
    - **Hospital-Level Factors:** Hospital region, Hospital bedsize, Hospital location and teaching status.
* **Software:** All statistical analyses were performed using R Statistical Language (Version 4.5.0; R Foundation for Statistical Computing, Vienna, Austria), incorporating survey-weighted procedures via the *survey* package to account for the complex sampling design of NIS.

## Baseline Table:

| **Characteristic** | **Overall** N = 126,015*1* | **TV-VVI** N = 115,520*1* | **Leadless Pacemaker** N = 10,495*1* | **p-value***2* |
| --- | --- | --- | --- | --- |
| Age, y | 78 (10) | 78 (10) | 76 (11) | <0.001 |
| Sex |  |  |  | 0.005 |
| Female | 54,970 (44%) | 50,695 (44%) | 4,275 (41%) |  |
| Male | 71,040 (56%) | 64,825 (56%) | 6,215 (59%) |  |
| Race |  |  |  | <0.001 |
| White | 92,175 (75%) | 85,060 (75%) | 7,115 (70%) |  |
| Asian or Pacific Islander | 3,865 (3.1%) | 3,425 (3.0%) | 440 (4.3%) |  |
| Black | 13,740 (11%) | 12,325 (11%) | 1,415 (14%) |  |
| Hispanic | 9,960 (8.1%) | 9,005 (8.0%) | 955 (9.3%) |  |
| Native American | 670 (0.5%) | 610 (0.5%) | 60 (0.6%) |  |
| Other | 2,710 (2.2%) | 2,460 (2.2%) | 250 (2.4%) |  |
| Residential income |  |  |  | 0.7 |
| $1 - $51,999 | 32,460 (26%) | 29,655 (26%) | 2,805 (27%) |  |
| $52,000 - $65,999 | 33,165 (27%) | 30,475 (27%) | 2,690 (26%) |  |
| $66,000 - $87,999 | 31,775 (26%) | 29,160 (26%) | 2,615 (25%) |  |
| $88,000 or more | 26,900 (22%) | 24,640 (22%) | 2,260 (22%) |  |
| Expected primary payer |  |  |  | 0.094 |
| Private | 10,140 (8.1%) | 9,385 (8.1%) | 755 (7.2%) |  |
| Medicaid | 3,825 (3.0%) | 3,425 (3.0%) | 400 (3.8%) |  |
| Medicare | 108,720 (86%) | 99,645 (86%) | 9,075 (87%) |  |
| Other | 3,220 (2.6%) | 2,965 (2.6%) | 255 (2.4%) |  |
| Hospital region |  |  |  | 0.13 |
| Midwest | 31,920 (25%) | 29,550 (26%) | 2,370 (23%) |  |
| Northeast | 22,310 (18%) | 20,375 (18%) | 1,935 (18%) |  |
| South | 46,020 (37%) | 42,095 (36%) | 3,925 (37%) |  |
| West | 25,765 (20%) | 23,500 (20%) | 2,265 (22%) |  |
| Hospital bedsize |  |  |  | <0.001 |
| Large | 70,740 (56%) | 63,815 (55%) | 6,925 (66%) |  |
| Medium | 35,220 (28%) | 32,780 (28%) | 2,440 (23%) |  |
| Small | 20,055 (16%) | 18,925 (16%) | 1,130 (11%) |  |
| Hospital location and teaching status |  |  |  | <0.001 |
| Rural | 6,010 (4.8%) | 5,775 (5.0%) | 235 (2.2%) |  |
| Urban, non-teaching | 21,875 (17%) | 20,600 (18%) | 1,275 (12%) |  |
| Urban, teaching | 98,130 (78%) | 89,145 (77%) | 8,985 (86%) |  |
| Charlson comorbidity index | 4.67 (1.64) | 4.65 (1.63) | 4.95 (1.69) | <0.001 |
| Admission Type |  |  |  | 0.3 |
| Elective | 16,670 (13%) | 15,355 (13%) | 1,315 (13%) |  |
| Non-elective | 109,170 (87%) | 100,000 (87%) | 9,170 (87%) |  |
| Chronic Kidney Disease Stage |  |  |  | <0.001 |
| CKD, Stage 1 | 550 (0.5%) | 510 (0.6%) | 40 (0.5%) |  |
| CKD, Stage 2 | 6,170 (6.1%) | 5,840 (6.3%) | 330 (3.7%) |  |
| CKD, Stage 3 | 63,745 (63%) | 59,820 (65%) | 3,925 (44%) |  |
| CKD, Stage 4 | 14,720 (15%) | 13,620 (15%) | 1,100 (12%) |  |
| CKD, Stage 5 | 1,130 (1.1%) | 985 (1.1%) | 145 (1.6%) |  |
| ESRD | 14,940 (15%) | 11,610 (13%) | 3,330 (38%) |  |
| Hypertension | 119,280 (95%) | 109,440 (95%) | 9,840 (94%) | 0.061 |
| Diabetes Mellitus | 65,895 (52%) | 60,295 (52%) | 5,600 (53%) | 0.3 |
| Obesity | 27,215 (22%) | 25,100 (22%) | 2,115 (20%) | 0.091 |
| Chronic Pulmonary Disease | 32,125 (25%) | 29,250 (25%) | 2,875 (27%) | 0.034 |
| Liver Disease | 6,085 (4.8%) | 5,275 (4.6%) | 810 (7.7%) | <0.001 |
| Peripheral Vascular Disease | 16,405 (13%) | 14,995 (13%) | 1,410 (13%) | 0.6 |
| Congestive Heart Failure | 75,085 (60%) | 67,900 (59%) | 7,185 (68%) | <0.001 |
| Myocardial Infarction | 26,150 (21%) | 23,970 (21%) | 2,180 (21%) | >0.9 |
| *1*Mean (SD); n (%) | | | | |
| *2*Design-based KruskalWallis test; Pearson's X^2: Rao & Scott adjustment | | | | |

## Univariable Analysis:

| **Characteristic** | **Overall** N = 126,015*1* | **TV-VVI** N = 115,520*1* | **Leadless Pacemaker** N = 10,495*1* | **p-value***2* |
| --- | --- | --- | --- | --- |
| Died during hospitalization | 3,140 (2.5%) | 2,550 (2.2%) | 590 (5.6%) | <0.001 |
| Length of stay (days) | 5 (3, 9) | 5 (3, 8) | 7 (4, 13) | <0.001 |
| Inflation-adjusted total charge ($) | 107,480 (67,447, 186,609) | 102,977 (65,598, 178,680) | 159,100 (105,158, 269,140) | <0.001 |
| Acute Kidney Injury | 58,990 (47%) | 54,360 (47%) | 4,630 (44%) | 0.012 |
| Any Complication | 12,390 (9.8%) | 10,420 (9.0%) | 1,970 (19%) | <0.001 |
| Vascular Complication | 1,235 (1.0%) | 980 (0.8%) | 255 (2.4%) | <0.001 |
| Pericardial Complication | 2,935 (2.3%) | 2,445 (2.1%) | 490 (4.7%) | <0.001 |
| Pneumothorax Complication | 2,110 (1.7%) | 2,015 (1.7%) | 95 (0.9%) | 0.004 |
| Infectious Complication | 230 (0.2%) | 150 (0.1%) | 80 (0.8%) | <0.001 |
| Device Complication | 7,000 (5.6%) | 5,740 (5.0%) | 1,260 (12%) | <0.001 |
| *1*n (%); Median (Q1, Q3) | | | | |
| *2*Pearson's X^2: Rao & Scott adjustment; Design-based KruskalWallis test | | | | |

## Multivariable Logistic Regression:

### In-hospital Mortality:

| **Characteristic** | **OR** | **95% CI** | **p-value** |
| --- | --- | --- | --- |
| Pacemaker Type |  |  |  |
| TV-VVI | — | — |  |
| Leadless Pacemaker | 1.83 | 1.41, 2.37 | <0.001 |
| Age, y | 1.01 | 1.0, 1.02 | 0.3 |
| Sex |  |  |  |
| Female | — | — |  |
| Male | 0.72 | 0.60, 0.87 | <0.001 |
| Race |  |  |  |
| White | — | — |  |
| Asian or Pacific Islander | 0.84 | 0.51, 1.39 | 0.5 |
| Black | 0.96 | 0.72, 1.28 | 0.8 |
| Hispanic | 0.89 | 0.64, 1.24 | 0.5 |
| Native American | 0.56 | 0.12, 2.49 | 0.4 |
| Other | 0.82 | 0.44, 1.53 | 0.5 |
| Residential income |  |  |  |
| $1 - $51,999 | — | — |  |
| $52,000 - $65,999 | 0.81 | 0.62, 1.06 | 0.13 |
| $66,000 - $87,999 | 0.98 | 0.76, 1.27 | >0.9 |
| $88,000 or more | 0.83 | 0.63, 1.10 | 0.2 |
| Expected primary payer |  |  |  |
| Private | — | — |  |
| Medicaid | 1.32 | 0.74, 2.33 | 0.3 |
| Medicare | 1.14 | 0.78, 1.66 | 0.5 |
| Other | 1.37 | 0.73, 2.56 | 0.3 |
| Hospital region |  |  |  |
| Midwest | — | — |  |
| Northeast | 0.74 | 0.55, 1.00 | 0.050 |
| South | 0.82 | 0.65, 1.04 | 0.10 |
| West | 0.92 | 0.71, 1.20 | 0.5 |
| Hospital bedsize |  |  |  |
| Large | — | — |  |
| Medium | 0.87 | 0.70, 1.09 | 0.2 |
| Small | 0.76 | 0.57, 1.01 | 0.055 |
| Hospital location and teaching status |  |  |  |
| Rural | — | — |  |
| Urban, non-teaching | 1.45 | 0.85, 2.49 | 0.2 |
| Urban, teaching | 1.26 | 0.76, 2.09 | 0.4 |
| Charlson comorbidity index | 1.12 | 1.03, 1.23 | 0.008 |
| Admission Type |  |  |  |
| Elective | — | — |  |
| Non-elective | 1.10 | 0.82, 1.47 | 0.5 |
| Chronic Kidney Disease Stage |  |  |  |
| CKD, Stage 1 | — | — |  |
| CKD, Stage 2 | 181,951 | 105,445, 313,966 | <0.001 |
| CKD, Stage 3 | 188,605 | 141,280, 251,785 | <0.001 |
| CKD, Stage 4 | 441,771 | 322,192, 605,730 | <0.001 |
| CKD, Stage 5 | 452,828 | 231,268, 886,650 | <0.001 |
| ESRD | 580,990 | 420,363, 802,996 | <0.001 |
| Hypertension |  |  |  |
| No | — | — |  |
| Yes | 0.50 | 0.35, 0.71 | <0.001 |
| Diabetes Mellitus |  |  |  |
| No | — | — |  |
| Yes | 0.80 | 0.61, 1.04 | 0.10 |
| Obesity |  |  |  |
| No | — | — |  |
| Yes | 0.59 | 0.45, 0.78 | <0.001 |
| Chronic Pulmonary Disease |  |  |  |
| No | — | — |  |
| Yes | 0.83 | 0.65, 1.04 | 0.11 |
| Liver Disease |  |  |  |
| No | — | — |  |
| Yes | 3.90 | 2.98, 5.12 | <0.001 |
| Peripheral Vascular Disease |  |  |  |
| No | — | — |  |
| Yes | 1.05 | 0.80, 1.38 | 0.7 |
| Congestive Heart Failure |  |  |  |
| No | — | — |  |
| Yes | 2.00 | 1.55, 2.57 | <0.001 |
| Myocardial Infarction |  |  |  |
| No | — | — |  |
| Yes | 1.87 | 1.53, 2.29 | <0.001 |
| Abbreviations: CI = Confidence Interval, OR = Odds Ratio | | | |

### Acute Kidney Injury:

| **Characteristic** | **OR** | **95% CI** | **p-value** |
| --- | --- | --- | --- |
| Pacemaker Type |  |  |  |
| TV-VVI | — | — |  |
| Leadless Pacemaker | 1.15 | 1.03, 1.29 | 0.013 |
| Age, y | 0.99 | 0.98, 0.99 | <0.001 |
| Sex |  |  |  |
| Female | — | — |  |
| Male | 0.98 | 0.92, 1.04 | 0.5 |
| Race |  |  |  |
| White | — | — |  |
| Asian or Pacific Islander | 1.41 | 1.18, 1.69 | <0.001 |
| Black | 1.04 | 0.94, 1.15 | 0.4 |
| Hispanic | 1.26 | 1.12, 1.42 | <0.001 |
| Native American | 0.83 | 0.55, 1.26 | 0.4 |
| Other | 1.45 | 1.19, 1.78 | <0.001 |
| Residential income |  |  |  |
| $1 - $51,999 | — | — |  |
| $52,000 - $65,999 | 1.01 | 0.92, 1.10 | 0.9 |
| $66,000 - $87,999 | 0.92 | 0.84, 1.01 | 0.073 |
| $88,000 or more | 0.97 | 0.88, 1.07 | 0.6 |
| Expected primary payer |  |  |  |
| Private | — | — |  |
| Medicaid | 0.97 | 0.78, 1.20 | 0.8 |
| Medicare | 0.89 | 0.79, 1.00 | 0.054 |
| Other | 1.07 | 0.85, 1.35 | 0.5 |
| Hospital region |  |  |  |
| Midwest | — | — |  |
| Northeast | 0.93 | 0.84, 1.03 | 0.15 |
| South | 1.04 | 0.96, 1.13 | 0.4 |
| West | 0.93 | 0.84, 1.02 | 0.12 |
| Hospital bedsize |  |  |  |
| Large | — | — |  |
| Medium | 1.02 | 0.95, 1.10 | 0.6 |
| Small | 1.02 | 0.93, 1.12 | 0.7 |
| Hospital location and teaching status |  |  |  |
| Rural | — | — |  |
| Urban, non-teaching | 1.21 | 1.03, 1.43 | 0.022 |
| Urban, teaching | 1.23 | 1.06, 1.43 | 0.008 |
| Charlson comorbidity index | 1.02 | 0.99, 1.06 | 0.2 |
| Admission Type |  |  |  |
| Elective | — | — |  |
| Non-elective | 2.06 | 1.87, 2.27 | <0.001 |
| Chronic Kidney Disease Stage |  |  |  |
| CKD, Stage 1 | — | — |  |
| CKD, Stage 2 | 1.71 | 1.11, 2.64 | 0.016 |
| CKD, Stage 3 | 2.40 | 1.58, 3.66 | <0.001 |
| CKD, Stage 4 | 3.95 | 2.58, 6.04 | <0.001 |
| CKD, Stage 5 | 3.68 | 2.21, 6.13 | <0.001 |
| ESRD | 0.37 | 0.24, 0.57 | <0.001 |
| Hypertension |  |  |  |
| No | — | — |  |
| Yes | 1.00 | 0.88, 1.15 | >0.9 |
| Diabetes Mellitus |  |  |  |
| No | — | — |  |
| Yes | 1.15 | 1.05, 1.26 | 0.003 |
| Obesity |  |  |  |
| No | — | — |  |
| Yes | 1.01 | 0.93, 1.09 | 0.8 |
| Chronic Pulmonary Disease |  |  |  |
| No | — | — |  |
| Yes | 0.99 | 0.92, 1.07 | 0.9 |
| Liver Disease |  |  |  |
| No | — | — |  |
| Yes | 1.70 | 1.46, 1.98 | <0.001 |
| Peripheral Vascular Disease |  |  |  |
| No | — | — |  |
| Yes | 0.99 | 0.89, 1.09 | 0.8 |
| Congestive Heart Failure |  |  |  |
| No | — | — |  |
| Yes | 1.76 | 1.64, 1.89 | <0.001 |
| Myocardial Infarction |  |  |  |
| No | — | — |  |
| Yes | 1.18 | 1.09, 1.28 | <0.001 |
| Abbreviations: CI = Confidence Interval, OR = Odds Ratio | | | |

### Any Complication:

| **Characteristic** | **OR** | **95% CI** | **p-value** |
| --- | --- | --- | --- |
| Pacemaker Type |  |  |  |
| TV-VVI | — | — |  |
| Leadless Pacemaker | 1.87 | 1.62, 2.16 | <0.001 |
| Age, y | 0.98 | 0.98, 0.99 | <0.001 |
| Sex |  |  |  |
| Female | — | — |  |
| Male | 0.90 | 0.81, 0.99 | 0.038 |
| Race |  |  |  |
| White | — | — |  |
| Asian or Pacific Islander | 0.96 | 0.73, 1.26 | 0.8 |
| Black | 1.04 | 0.89, 1.21 | 0.7 |
| Hispanic | 1.00 | 0.83, 1.21 | >0.9 |
| Native American | 0.49 | 0.19, 1.26 | 0.14 |
| Other | 1.04 | 0.73, 1.49 | 0.8 |
| Residential income |  |  |  |
| $1 - $51,999 | — | — |  |
| $52,000 - $65,999 | 0.92 | 0.80, 1.05 | 0.2 |
| $66,000 - $87,999 | 0.93 | 0.81, 1.07 | 0.3 |
| $88,000 or more | 1.00 | 0.86, 1.17 | >0.9 |
| Expected primary payer |  |  |  |
| Private | — | — |  |
| Medicaid | 1.03 | 0.75, 1.41 | 0.9 |
| Medicare | 1.03 | 0.86, 1.24 | 0.7 |
| Other | 1.27 | 0.93, 1.74 | 0.13 |
| Hospital region |  |  |  |
| Midwest | — | — |  |
| Northeast | 0.80 | 0.69, 0.94 | 0.007 |
| South | 0.92 | 0.81, 1.04 | 0.2 |
| West | 0.93 | 0.81, 1.07 | 0.3 |
| Hospital bedsize |  |  |  |
| Large | — | — |  |
| Medium | 0.86 | 0.76, 0.97 | 0.011 |
| Small | 0.77 | 0.66, 0.89 | <0.001 |
| Hospital location and teaching status |  |  |  |
| Rural | — | — |  |
| Urban, non-teaching | 0.95 | 0.72, 1.26 | 0.7 |
| Urban, teaching | 1.29 | 1.00, 1.66 | 0.047 |
| Charlson comorbidity index | 0.98 | 0.92, 1.03 | 0.4 |
| Admission Type |  |  |  |
| Elective | — | — |  |
| Non-elective | 0.58 | 0.51, 0.66 | <0.001 |
| Chronic Kidney Disease Stage |  |  |  |
| CKD, Stage 1 | — | — |  |
| CKD, Stage 2 | 0.72 | 0.40, 1.31 | 0.3 |
| CKD, Stage 3 | 0.83 | 0.47, 1.46 | 0.5 |
| CKD, Stage 4 | 0.81 | 0.46, 1.45 | 0.5 |
| CKD, Stage 5 | 1.12 | 0.57, 2.18 | 0.7 |
| ESRD | 1.22 | 0.69, 2.16 | 0.5 |
| Hypertension |  |  |  |
| No | — | — |  |
| Yes | 0.81 | 0.66, 1.00 | 0.048 |
| Diabetes Mellitus |  |  |  |
| No | — | — |  |
| Yes | 0.82 | 0.71, 0.95 | 0.008 |
| Obesity |  |  |  |
| No | — | — |  |
| Yes | 0.88 | 0.77, 0.99 | 0.039 |
| Chronic Pulmonary Disease |  |  |  |
| No | — | — |  |
| Yes | 1.10 | 0.97, 1.25 | 0.14 |
| Liver Disease |  |  |  |
| No | — | — |  |
| Yes | 1.46 | 1.19, 1.79 | <0.001 |
| Peripheral Vascular Disease |  |  |  |
| No | — | — |  |
| Yes | 1.30 | 1.13, 1.50 | <0.001 |
| Congestive Heart Failure |  |  |  |
| No | — | — |  |
| Yes | 1.28 | 1.13, 1.44 | <0.001 |
| Myocardial Infarction |  |  |  |
| No | — | — |  |
| Yes | 0.93 | 0.81, 1.06 | 0.3 |
| Abbreviations: CI = Confidence Interval, OR = Odds Ratio | | | |

## Multivariable Linear Regression:

### Length of Stay:

| **Characteristic** | **Beta** | **95% CI** | **p-value** |
| --- | --- | --- | --- |
| Pacemaker Type |  |  |  |
| TV-VVI | — | — |  |
| Leadless Pacemaker | 2.7 | 2.0, 3.3 | <0.001 |
| Age, y | -0.10 | -0.12, -0.08 | <0.001 |
| Sex |  |  |  |
| Female | — | — |  |
| Male | -0.35 | -0.57, -0.13 | 0.002 |
| Race |  |  |  |
| White | — | — |  |
| Asian or Pacific Islander | 0.90 | 0.10, 1.7 | 0.028 |
| Black | 0.73 | 0.32, 1.1 | <0.001 |
| Hispanic | 0.62 | 0.02, 1.2 | 0.041 |
| Native American | -0.87 | -2.5, 0.72 | 0.3 |
| Other | 1.6 | 0.37, 2.8 | 0.010 |
| Residential income |  |  |  |
| $1 - $51,999 | — | — |  |
| $52,000 - $65,999 | -0.17 | -0.51, 0.17 | 0.3 |
| $66,000 - $87,999 | -0.28 | -0.63, 0.06 | 0.11 |
| $88,000 or more | -0.13 | -0.50, 0.25 | 0.5 |
| Expected primary payer |  |  |  |
| Private | — | — |  |
| Medicaid | 0.57 | -0.86, 2.0 | 0.4 |
| Medicare | -0.85 | -1.4, -0.27 | 0.004 |
| Other | -0.29 | -1.3, 0.67 | 0.6 |
| Hospital region |  |  |  |
| Midwest | — | — |  |
| Northeast | 0.67 | 0.29, 1.1 | <0.001 |
| South | 0.39 | 0.06, 0.72 | 0.022 |
| West | -0.61 | -0.98, -0.24 | 0.001 |
| Hospital bedsize |  |  |  |
| Large | — | — |  |
| Medium | -0.90 | -1.2, -0.62 | <0.001 |
| Small | -1.1 | -1.4, -0.78 | <0.001 |
| Hospital location and teaching status |  |  |  |
| Rural | — | — |  |
| Urban, non-teaching | 1.0 | 0.52, 1.5 | <0.001 |
| Urban, teaching | 1.7 | 1.3, 2.1 | <0.001 |
| Charlson comorbidity index | 0.59 | 0.42, 0.75 | <0.001 |
| Admission Type |  |  |  |
| Elective | — | — |  |
| Non-elective | 0.64 | 0.28, 0.99 | <0.001 |
| Chronic Kidney Disease Stage |  |  |  |
| CKD, Stage 1 | — | — |  |
| CKD, Stage 2 | -0.54 | -2.1, 1.0 | 0.5 |
| CKD, Stage 3 | 0.00 | -1.5, 1.5 | >0.9 |
| CKD, Stage 4 | 0.73 | -0.81, 2.3 | 0.4 |
| CKD, Stage 5 | 1.4 | -0.51, 3.3 | 0.2 |
| ESRD | 2.9 | 1.3, 4.5 | <0.001 |
| Hypertension |  |  |  |
| No | — | — |  |
| Yes | -1.2 | -1.9, -0.47 | 0.001 |
| Diabetes Mellitus |  |  |  |
| No | — | — |  |
| Yes | -1.5 | -1.9, -1.1 | <0.001 |
| Obesity |  |  |  |
| No | — | — |  |
| Yes | -0.21 | -0.49, 0.08 | 0.2 |
| Chronic Pulmonary Disease |  |  |  |
| No | — | — |  |
| Yes | -0.38 | -0.67, -0.08 | 0.012 |
| Liver Disease |  |  |  |
| No | — | — |  |
| Yes | 2.7 | 1.8, 3.6 | <0.001 |
| Peripheral Vascular Disease |  |  |  |
| No | — | — |  |
| Yes | -0.14 | -0.50, 0.22 | 0.4 |
| Congestive Heart Failure |  |  |  |
| No | — | — |  |
| Yes | 2.0 | 1.7, 2.2 | <0.001 |
| Myocardial Infarction |  |  |  |
| No | — | — |  |
| Yes | 0.20 | -0.15, 0.55 | 0.3 |
| Abbreviation: CI = Confidence Interval | | | |

### Inflation-adjusted Total Charge:

| **Characteristic** | **Beta** | **95% CI** | **p-value** |
| --- | --- | --- | --- |
| Pacemaker Type |  |  |  |
| TV-VVI | — | — |  |
| Leadless Pacemaker | 58,461 | 44,399, 72,523 | <0.001 |
| Age, y | -2,334 | -2,802, -1,867 | <0.001 |
| Sex |  |  |  |
| Female | — | — |  |
| Male | 3,989 | -1,212, 9,190 | 0.13 |
| Race |  |  |  |
| White | — | — |  |
| Asian or Pacific Islander | 29,403 | 3,473, 55,333 | 0.026 |
| Black | 5,609 | -3,886, 15,104 | 0.2 |
| Hispanic | 29,839 | 17,183, 42,495 | <0.001 |
| Native American | -43,751 | -79,645, -7,858 | 0.017 |
| Other | 61,472 | 32,603, 90,341 | <0.001 |
| Residential income |  |  |  |
| $1 - $51,999 | — | — |  |
| $52,000 - $65,999 | 611 | -7,102, 8,325 | 0.9 |
| $66,000 - $87,999 | 2,145 | -5,597, 9,887 | 0.6 |
| $88,000 or more | 6,523 | -2,413, 15,458 | 0.2 |
| Expected primary payer |  |  |  |
| Private | — | — |  |
| Medicaid | 671 | -24,343, 25,684 | >0.9 |
| Medicare | -5,731 | -19,677, 8,215 | 0.4 |
| Other | 3,205 | -22,181, 28,590 | 0.8 |
| Hospital region |  |  |  |
| Midwest | — | — |  |
| Northeast | 29,766 | 20,630, 38,902 | <0.001 |
| South | 31,975 | 24,065, 39,886 | <0.001 |
| West | 67,964 | 52,654, 83,275 | <0.001 |
| Hospital bedsize |  |  |  |
| Large | — | — |  |
| Medium | -24,833 | -33,618, -16,048 | <0.001 |
| Small | -28,480 | -37,720, -19,240 | <0.001 |
| Hospital location and teaching status |  |  |  |
| Rural | — | — |  |
| Urban, non-teaching | 42,318 | 32,764, 51,872 | <0.001 |
| Urban, teaching | 58,348 | 50,000, 66,695 | <0.001 |
| Charlson comorbidity index | 5,550 | 2,417, 8,683 | <0.001 |
| Admission Type |  |  |  |
| Elective | — | — |  |
| Non-elective | -81,702 | -91,781, -71,624 | <0.001 |
| Chronic Kidney Disease Stage |  |  |  |
| CKD, Stage 1 | — | — |  |
| CKD, Stage 2 | -13,528 | -46,538, 19,483 | 0.4 |
| CKD, Stage 3 | -11,882 | -45,781, 22,017 | 0.5 |
| CKD, Stage 4 | 508 | -33,707, 34,724 | >0.9 |
| CKD, Stage 5 | 3,154 | -40,218, 46,526 | 0.9 |
| ESRD | 53,244 | 16,947, 89,542 | 0.004 |
| Hypertension |  |  |  |
| No | — | — |  |
| Yes | -22,978 | -40,899, -5,057 | 0.012 |
| Diabetes Mellitus |  |  |  |
| No | — | — |  |
| Yes | -22,092 | -30,342, -13,841 | <0.001 |
| Obesity |  |  |  |
| No | — | — |  |
| Yes | -4,550 | -11,561, 2,461 | 0.2 |
| Chronic Pulmonary Disease |  |  |  |
| No | — | — |  |
| Yes | -4,319 | -10,994, 2,355 | 0.2 |
| Liver Disease |  |  |  |
| No | — | — |  |
| Yes | 59,160 | 36,875, 81,446 | <0.001 |
| Peripheral Vascular Disease |  |  |  |
| No | — | — |  |
| Yes | 4,933 | -3,120, 12,985 | 0.2 |
| Congestive Heart Failure |  |  |  |
| No | — | — |  |
| Yes | 43,534 | 37,086, 49,982 | <0.001 |
| Myocardial Infarction |  |  |  |
| No | — | — |  |
| Yes | 16,573 | 8,490, 24,657 | <0.001 |
| Abbreviation: CI = Confidence Interval | | | |