

Healthcare Utilization and Costs in Patients with Atrial Fibrillation before and After Hybrid Ablation

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Abstract

Background: Hybrid epicardial with endocardial ablation is an effective treatment for patients with AF. Limited data are available regarding healthcare utilization and hospital costs after treatment. This study sought to assess the impact of hybrid ablation for atrial fibrillation (AF) on post-treatment healthcare utilization and hospital costs.

Methods: Using a large Medicare administrative database, patients treated with hybrid ablation were retrospectively evaluated 1-year prior to and 1-2 years following ablation for inpatient admissions, hospital length of stay, emergency department (ED) visits, cardioversions, repeat catheter ablations, and hospital costs (per member per month, PMPM).

Results: 472 patients with paroxysmal and non-paroxysmal AF with an average CHA₂DS₂-VASc score of 3.4 were included. Compared to pre-hybrid ablation, resource use and costs decreased in the second year following treatment. Reductions were observed for annual per patient hospital admissions (50%, p<0.0001), ED visits (38%, p<0.0001), cardioversions (84%, p<0.0001), and catheter ablations (46%, p<0.0049). By year two, primary AF hospital admissions decreased by 79%, average hospital days decreased from 1.9 days to 0.9 days, and total hospital costs were reduced by 11% per patient (-\$119, PMPM; p<0.001). Reductions in inpatient (20%, -\$93 PMPM; p=0.04) and outpatient (13%, -\$74 PMPM; p<0.0001) costs were observed.

Conclusions: Hybrid ablation for AF reduced healthcare utilization and hospital costs by the second year following treatment.

Introduction

Atrial fibrillation (AF) is the most common cardiac arrhythmia and increases the risk for stroke, heart failure (HF) and cardiovascular morbidity¹. In the United States (US) approximately 3 to 6 million patients present with AF at any given time²⁻³. Estimates suggest that AF is responsible for more than 500,000 yearly emergency department (ED) visits⁴ with an annual yearly expenditure of \$15,000- \$40,000 per patient following diagnosis⁵⁻⁸.

Several therapies are used to treat AF, including pharmacological management, catheter ablation, and more recently hybrid ablation. As patients progress in disease severity, stand-alone catheter ablation is typically used to treat paroxysmal AF, while both catheter ablation and hybrid ablation therapies are used as AF progresses in disease severity. Hybrid ablation therapy for AF treatment is a newer therapy and combines minimally invasive epicardial surgical ablation with endocardial catheter ablation. A surgeon and an electrophysiologist perform the 2-step procedure using a heart team approach.

Key Words

Hybrid Ablation, Atrial Fibrillation, Healthcare Utilization, Hospital Cost, Admissions

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Hybrid ablation for AF has demonstrated improved clinical outcomes as compared to stand-alone catheter ablation for AF patients by improving freedom from AF on/off previously failed antiarrhythmic drugs and reduces AF burden⁹⁻¹². The 2017 HRS/EHRA/ECAS/APHRS/ SOLAECE expert consensus statement on catheter and surgical ablation of AF recommends AF hybrid ablation as a

**Figure 1:**

Study design, including 12-month look back for pre-treatment period, index hybrid ablation treatment period, and 2-year post-treatment period.

reasonable (class of recommendation IIb) option in selected patients with persistent and long-standing persistent AF (non-paroxysmal) ¹.

Increasing incidence of AF and the associated cost of therapies should prompt consideration for evaluating long term resource utilization for management and subsequent clinical guidelines updates. The impact of hybrid ablation on subsequent healthcare utilization and cost reductions among patients with AF has not been well studied. The recognition of downstream resource utilization could drive health policy decisions. Therefore, the objective of this study was to examine healthcare use and cost among Medicare beneficiaries with AF before and after hybrid ablation treatment in a real-world setting using a contemporary administrative data set.

Materials and Methods

Data Source

Data were obtained from the Medicare 100% inpatient and outpatient standard analytic files (SAF) and Master Beneficiary Summary Files. Medicare is a federal health insurance program in the US which provides coverage for persons more than or equal to 65 years of age, patients less than 65 years of age who are fully disabled, and those with end-stage renal disease. Pharmacy data was not available in the claims data set. This study was provided exempt status by the Sterling institutional review board (Atlanta, GA).

Study Population

Medicare patients with AF undergoing hybrid ablation between October 1, 2016, and September 30, 2018, were identified using International Classification of Diseases-10th Revision-Clinical Modification (ICD-10-CM) diagnosis codes for AF and ICD-10 Procedure Coding System (ICD-10-PCS) and Current Procedural Terminology (CPT®) procedure codes for hybrid ablation. Patients were categorized as either paroxysmal or non-paroxysmal (persistent, chronic, unspecified) AF (Supplemental Table 1). We used data from 1 year before the surgical ablation segment of the hybrid procedure for a look-back period and 2 years of data post the catheter ablation segment of the index hybrid procedure (Figure 1).

Hybrid ablation procedures for AF were performed either during the same inpatient stay (epicardial surgical ablation with endocardial catheter ablation during the same inpatient stay) or sequential spaced (epicardial surgical ablation followed by a post-discharge endocardial catheter ablation performed either inpatient or outpatient within 90 days of the epicardial surgical ablation).

Patients were excluded from the analysis if they were not enrolled in Medicare Part A and Part B during the study period. Other exclusion factors included those electing HMO insurance, patients missing demographic information and patients who had a prior surgical ablation within 1 year prior to the index surgical ablation. The final study population consisted of 472 patients and cohort formation is listed in Figure 2.

Clinical Outcomes and Healthcare Resources

Index procedure variables reported included inpatient length of stay (LOS) and use of surgical left atrial appendage device. The 1-year period prior to the hybrid ablation index admission was used for the pre-period analysis. Data from both hybrid groups were combined for post-treatment comparisons due to the small sample size. The post-period started following the endocardial ablation component of the procedure, either the day after the inpatient discharge or the day after if the endocardial procedure was performed as an outpatient procedure. The post-hybrid ablation procedure period was divided into two one-year follow-up periods. Patients who died during the study period (n=24) were removed from the outcomes analysis, so each remaining patient had the same amount of follow-up time in the post-period. Outcomes including these patients were directionally the same as when excluded but more likely to reach statistical significance when excluded.

Clinical diagnoses and procedures occurring in the study period were identified in the Medicare inpatient and outpatient hospital admissions claims using ICD-10-CM and PCS codes (Supplemental Table 2). Patient risk variables consisted of a calculated Charlson Comorbidity

Table 1: Patient Demographics and Treatment Location

Hybrid Ablation for AF				
	Overall (n=472)	Same Day (n=239)	Sequential (n=233)	P Value
Demographic Characteristics				
Age, yrs				
Mean ±SD	71 (5.6)	71 (5.8)	71 (5.4)	P=0.38
Sex				
Female	175 (37)	88 (37)	86 (37)	P=0.91
Male	297 (63)	151 (63)	147 (63)	
Race				
White	439 (93)	224 (94)	215 (92)	P=0.54
Non-White	33 (7)	15 (6)	18 (8)	
AF type				
Paroxysmal	120 (25)	53 (22)	67 (29)	P=0.10
Non-paroxysmal	352 (75)	186 (78)	166 (71)	
Disabled or ESRD	64 (14)	31 (13)	33 (14)	P=0.71
Dually eligible for Medicaid	23 (5)	*	^	P=0.12
Region				
Northeast	47 (10)	41 (17)	* (*)	P<0.001
Midwest	42 (9)	20 (8)	^ (*)	
South	289 (61)	160 (67)	129 (55)	
West	94 (20)	18 (8)	76 (33)	

Values are means ± SD for continuous variables, n (%) and frequencies for categorical variables; Abbreviations: AF, atrial fibrillation; ESRD, end stage renal disease;

* Indicates a value of 10 or less, blinded per privacy regulations;

^ Indicates a value greater than 10 that could lead to the calculation of a value of 10 or less

Table 2: Patient Risk and Comorbidity Status

	Hybrid Ablation for AF			P Value
	Overall (n=472)	Same Day (n=239)	Sequential (n=233)	
Clinical Risk				
CCI	4.3 (1.8)	4.3 (1.7)	4.4 (1.9)	P=0.43
ECI	3.9 (2.6)	3.8 (2.6)	3.9 (2.6)	P=0.49
CHA ₂ DS ₂ -VaSc	3.4 (1.5)	3.3 (1.5)	3.6 (1.4)	P=0.90
HAS-Bled	2.3 (0.9)	2.3 (0.9)	2.4 (0.9)	P=0.15
Comorbidity or History				
Arrhythmia, other	200 (42)	88 (37)	112 (48)	P=0.01
Cardiomyopathy	77 (16)	48 (20)	29 (12)	P=0.02
CVD	60 (13)	28 (12)	32 (14)	P=0.51
CHF	127 (27)	67 (28)	60 (26)	P=0.58
CLD	93 (20)	44 (18)	49 (21)	P=0.47
Depression	44 (9)	30 (12)	14 (6)	P=0.01
Diabetes with chronic complications	63 (13)	34 (14)	29 (12)	P=0.57
Diabetes without chronic complications	122 (26)	63 (26)	59 (25)	P=0.80
Hypertension, complicated	72 (15)	35 (15)	37 (16)	P=0.71
Hypertension, uncomplicated	357 (76)	173 (72)	184 (79)	P=0.10
MI history	14 (3)	*	*	P=0.62
Obesity	145 (31)	69 (29)	76 (33)	P=0.38
PVD	81 (17)	36 (15)	45 (19)	P=0.22
Sleep disorder	163 (35)	78 (33)	85 (37)	P=0.38
Stroke, any	27 (6)	12 (5)	15 (6)	P=0.51
Valve disease	176 (37)	71 (30)	105 (45)	P=0.006

Values are mean $\pm$ SD, n (%).

Abbreviations: AF, atrial fibrillation; CCI, Charlson comorbidity index; CVD, cerebrovascular disease; CHF, congestive heart failure; CLD, chronic lung disease; ECI, Elixhauser Comorbidity Index; MI, myocardial infarction; PVD, peripheral vascular disease;

* Indicates a value of 10 or less, blinded per privacy regulations.

Index score (CCI)¹³⁻¹⁵, a summary of Exhausters conditions¹⁶, CHA₂DS₂-VASc scores¹⁷⁻¹⁸ for AF stroke risk, HAS-BLED¹⁹ scores for major bleeding and specific comorbid conditions (heart failure, hypertension, etc.).

Health care utilization variables consisted of ED claims, inpatient admission variables (presence, readmission presence in 1 and 2 years, average number of readmissions in 1 and 2 years, average number of days for all inpatient admissions within 1 and 2 years, average admission days to 1st readmission in 2 years), cardioversions and endocardial catheter ablation procedures not included in the index procedure. Health care costs were defined as the amount paid by the Medicare program including beneficiary cost sharing, as recorded on the inpatient and outpatient hospital facility claims. Costs were capped at the 99th percentile to eliminate outliers in each cost category (inpatient, outpatient, total and admission costs). Costs were expressed as per member per month (PMPM). Costs were not indexed for inflation.

Statistical Analysis

Means and standard deviations were reported for continuous variables and frequencies, and percentages were reported for categorical variables. Baseline same day and sequential hybrid ablation groups were compared with the chi-square test of independence. Due to the small

sample size, same day and sequential hybrid ablation procedures were combined for pre- and post-procedure analysis using the Wilcoxon signed-rank test or Student T-test depending on data distributions. 95% confidence intervals were estimated. Data were capped at the 99th percentile to account for utilization and medical cost outliers. Given the small sample of patients with mortality (n=24, 5.1%) during the follow-up period, these patients were excluded in the analysis to hold the population, time frames and measurements constant.

To further explain variation in health care cost or utilization change, multivariate regression analyses were performed. In all analyses, a two-sided p-value less than 0.05 was the threshold for which differences were considered to be significant. All analyses were performed using SAS software version 9.4 (Cary, North Carolina).

Results

Baseline Characteristics

Patient characteristics and procedure locations are presented in Table 1 and 2. There were 472 patients that met study inclusion, including 239 patients in the same-day hybrid group and 233 in the sequential hybrid group. The mean patient age was 71 ± 6 years and 63% were male. There were no differences in rates of AF between same-stay and sequential hybrid procedure groups. However, there was an approximate 3:1 ratio of non-paroxysmal to paroxysmal patients in the current study. Before the study entry, 11.7% (N=55) of patients had prior endocardial catheter ablation. A majority of study patients had a history of hypertension. Other common clinical comorbidities included other arrhythmias, congestive heart failure (CHF), chronic lung disease, diabetes, obesity, sleep disorders and valvular disease. Same-stay hybrid patients had slightly higher rate of cardiomyopathy (20% vs. 12%, p=0.02), whereas sequential hybrid patients presented with a greater history of other arrhythmias (48 % vs. 37%, p=0.01) and valvular disease (45% vs. 30%, p<0.001). Patients presented with a moderate clinical risk demonstrated by Charlson Comorbidity Index (CCI) scores of 4.3 and a CHA₂DS₂-VaSc score of 3.4.

Out of all procedures in this study, 28% included an extraluminal epicardial surgical exclusion device to manage the left atrial appendage (LAA), with more sequential hybrid procedures using a LAA device (47% vs. 9%, p<0.001). The average LOS for all hybrid procedures was 4.0 ± 2.1 days, with no differences between same-day and sequential hybrid procedure (4.1 vs. 3.8 days, p=0.1579). 89 % of the endocardial ablation procedures in the sequential hybrid ablation group were performed as outpatient procedures. Most hybrid ablation procedures were performed in the South or Western regions of the US.

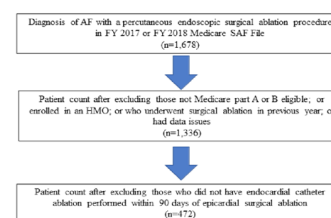


Figure 2: Attrition flow diagram, with inclusion criteria used to select patients in the analysis. AF, atrial fibrillation; SAF, standard analytic file; HMO, health maintenance organization.

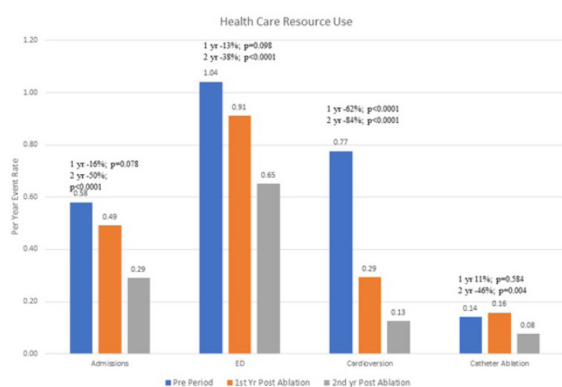


Figure 3: Change in healthcare utilization pre- and post-AF hybrid ablation. ED, emergency department; AF, atrial fibrillation.

Mortality during the index procedure stay was extremely rare (not reportable due to CMS data use when $n < 11$), and no patient deaths were reported within the first week following the procedure, suggesting mortality was not procedure related.

Post Hybrid Ablation Hospital Utilization

Health care utilization was significantly lower for AF patients following hybrid ablation (Figure 3). 9% of patients had a 30-day readmission. Average annual hospital admission rates decreased 16% (0.58 vs. 0.49 events) during year one (95% CI: -0.01, -0.20; $p < 0.078$) and 50% (0.58 vs. 0.29 events) during year two (95% CI: -0.20, -0.39; $p < 0.0001$) compared to the pre-treatment period. The maximum number of hospital admissions over time for any patient decreased from 6 events in the pre-treatment period to 2 events in the second-year post-treatment. 38% of patients had at least one a hospital admission in the year before treatment, 32% had at least one hospital admission in the year following treatment ($p = 0.03$), and 24% had at least one hospital admission in the second year following treatment ($p < 0.0001$). AF as the primary diagnosis for hospital admission decreased by 56% and 79% one- and two-years post-treatment, respectively. Average hospital admission LOS dropped from 1.9 days to 0.9 days (95% CI: -1.35, -0.65; $p < 0.0001$) during year two. The first occurrence of hospital admission following hybrid ablation was 253 ± 223 days.

Similar trends were noted for ED visits, cardioversion, and catheter ablation. Average annual ED visits decreased by 13% (1.04 vs. 0.91 events) in year one (95% CI: -0.27, -0.02; $p = 0.098$) and 38% (1.04 vs. 0.65 events) in year two (95% CI: -0.52, -0.25; $p < 0.0001$) compared to the pre-treatment period. The maximum number of ED visits for any given patient in the pre-treatment period decreased from 6 events to 4 events by 2 years post-treatment. AF as the primary diagnosis for ED visits decreased by 63% and 73% one- and two-years post-treatment. Average annual cardioversions decreased by 62% (0.77 vs. 0.29 events) in year one (95% CI: -0.59, -0.38; $p < 0.0001$) and 83% (0.77 vs. 0.13 events) in year two (95% CI: -0.75, -0.55; $p < 0.0001$) compared to the pre-treatment. 48% of patients had at least one cardioversion during the pre-hybrid ablation treatment period and 10% had a cardioversion during year two ($p < 0.0226$). Average annual catheter ablations increased by 11% (0.14 vs. 0.16 events) in year one

(95% CI: -0.04, 0.07; $p = 0.5841$) and decreased by 46% (0.14 vs. 0.08 events) in year two (95% CI: -0.11, -0.02; $p < 0.0049$) compared to pre-treatment. 16% of patients had at least one catheter ablation during the pre-treatment period and 8% had at least one catheter ablation during year two ($p < 0.0226$). In follow-up 11% of patients had pacemaker, implantable cardiac defibrillator (ICD), cardiac resynchronization therapy (CRT) device implant and 4% of patients underwent atrio ventricular (AV) node ablation.

Post Hybrid Ablation Hospital Costs

There was a significant reduction in annual all-cause hospital costs for AF patients treated with hybrid ablation by year two (Figure 4). Total annual hospital costs were reduced by 11% per patient (-\$119 PMPM, 95% CI: -\$63, -\$301; $P < 0.001$) in the second year compared to pre-treatment. No significant changes were found in the first year after hybrid ablation. Total inpatient hospital costs were reduced by 20% per patient (-\$93 PMPM, 95% CI: -\$31, -\$218; $P = 0.04$) in the second year compared to pre-treatment. No significant changes were found in the first year. Total outpatient hospital costs were reduced by 13% per patient (-\$75 PMPM, 95% CI: -\$24, -\$173; $P < 0.0001$) in the second year compared to pre-treatment. Small significant reductions in outpatient costs were noted in the first year (-\$8 PMPM, 95% CI: -\$91, -\$107; $P = 0.03$).

Although this study did not assess cost effectiveness due to the lack of long-term follow-up claims data available at this time, the average Medicare cost of the procedure including patient cost-sharing was \$37,776 (same-day hybrid procedure) and \$51,999 (sequential procedures combined).

Factors Associated with Changes in Health Care Costs and Utilization

Multivariate regression analyses were used to identify predictor variables of change ($p < .05$) in cost and utilization (Supplemental Table 3). Older age was associated with increases in cost and utilization in five of ten models. Reduced resource use and costs were observed following hybrid ablation. Midwestern U.S. patients had the most decreased total hospital costs and the reason for regional variation is unknown. Having a hybrid ablation procedure, use of surgical LAA, baseline CHF status, being female and having baseline diabetes had little impact on resource use or cost.

Discussion

AF is a chronic progressive disease which requires continuous management. Interventional strategies for rhythm control may provide both acute and chronic benefit to patients and healthcare systems. The recognition of downstream impact in managing this population and mitigating healthcare utilization is important to guide therapy decisions. Patients in this study were Medicare beneficiaries presenting with AF, with several baseline comorbidities and increased medical risk. Approximately half of the patients had a cardioversion in the previous year for atrial arrhythmias prior to hybrid ablation. The benefits of AF rhythm control with hybrid ablation in AF patients are well documented and include reduction of symptomatic AF as well as overall reduced AF burden^{9,12,20}. Single- and multicenter studies have reported freedom from AF or any atrial tachyarrhythmia to be 66%–

95% at 1 year after the hybrid AF ablation procedure, with 52%–81% arrhythmia-free without antiarrhythmic drugs²¹. This study continued prior work in this area by exploring the impact of hybrid ablation on hospital resource utilization and costs.

This study of hybrid ablation for AF shows significantly reduced hospital utilization through fewer patient admissions, hospital days, cardioversions, and rate of catheter ablations. Although reductions in hospital utilization were present in the first-year post-hybrid procedure, the largest reduction was observed during year two. It is likely that ablation for focal arrhythmias to achieve durable rhythm control during the first year following initial treatment may explain some of these differences. Maesen et al.²² found that additional ablations were required in 26% of patients who underwent hybrid ablation for AF. This is not surprising given that hybrid ablation patients are typically sicker, with more non-paroxysmal AF patients requiring additional treatment. Other measures of resource utilization decreased, such as the maximum number of admissions from the pre-intervention to the post-intervention period (6 to 4), and a significant average period (253 days) post-treatment for first hospital admission. Older patients had a propensity to have greater healthcare usage. These results suggest that hybrid ablation for AF treatment may be effective at reducing hospital resource use. Our results are consistent with other published studies. A recent study using administrative data of catheter ablation for AF demonstrated a significant reduction in AF-related hospital admissions (66%), ED visits (55%), and cardioversions (53%) following endocardial catheter ablation²³. Although some patients had pacemaker/ICD/CRT device implant and AV node ablation, more than likely other rhythm disturbances (i.e., bradycardia) were reasons for these interventions. A high proportion of patients in this study had a history of other non-AF rhythms. A recent FDA IDE study found 5.9% of patients with hybrid ablation for AF required pacemakers in follow-up for non-AF reasons (unpublished data)⁹.

As a result of reduced hospital resource use, there were lower hospital costs following the hybrid AF treatment. Year one costs were comparable to pre-treatment costs. However, by year two, significant reductions were found for both inpatient and outpatient total hospital costs. Reductions in costs were most likely attributed to less hospital resource use typically associated with AF treatment. DeLurgio et al.⁹ observed 53% of patients discontinued antiarrhythmic medications

following hybrid therapy. Cost reductions following hybrid ablation were likely to be underestimated given the probable discontinuation of antiarrhythmic drug use following ablation. Similarly, estimates of annual costs for Warfarin and novel oral anticoagulants range from as low as ~\$400 to over \$4,000 per year, suggesting possible lowered pharmacy costs for hybrid therapy in this study²⁴. Since less than half of the patients received surgical LAA management, the impact on oral anticoagulant (OAC) status is unclear. We assumed OAC status remained unchanged, but the recent LAAOS III study observed approximately a 20% reduction in OAC use following surgical LAA management with open heart procedures²⁵.

Current study results are also consistent with others examining cost impact following AF treatment^{23,26}. We examined the cost impact of hybrid AF ablation before and following intervention, with the exclusion of procedure costs. Adding procedure cost would require a longer follow-up time period than is available to compare cost-effectiveness. However, in a modeling study, hybrid epicardial with endocardial ablation for AF considering index costs demonstrated cost effectiveness compared to catheter ablation or medical management over a 5-year time period based on a predicted reduction in resource use post-treatment²⁷. Given the newness of hybrid ablation there were not adequate long-term claims data to compare with catheter ablation. However, this should be considered going forward. Overall, these findings are significant from a health policy perspective, as payors are mindful of monthly costs of disease treatments and strategies to reduce costs.

Limitations

There were multiple limitations in this study. Administrative databases contain less clinical information than a dedicated clinical database, may be prone to selection bias and are meant for a representation of care provided for payment agreements. Secondly, physicians' fees and drug costs were not available. This most likely led to underreporting of cost savings. Thirdly, a comparative analysis with catheter ablation would not have been appropriate because of the time required to show cost-effectiveness relative to catheter ablation is not available at this time. Lastly, the cohort were older Medicare beneficiaries, with many comorbidities. These results may not be generalizable to younger, less sick patients. Nonetheless, this data set provides valuable insights on resource use and cost associated with hybrid ablation therapy for AF.

Conclusions

In conclusion, this study demonstrates that hybrid ablation performed either during same-stay or sequential visits for hard-to-treat AF reduces healthcare resource use longitudinally at one- and two-years following intervention. Reductions in healthcare utilization were driven by fewer hospital admissions, ED visits, cardioversions and repeat catheter ablation procedures. Future resource mitigation studies should include the impact of hybrid ablation on anti-arrhythmic and anticoagulant medications.

Disclosures

Dr. Lee, Dr. Ferguson and Mr. Kerins are employees of AtriCure. Dr. Billakanty and Amin report consulting fees from AtriCure. Braid-Forbes Health Research report fees from AtriCure for data analysis.

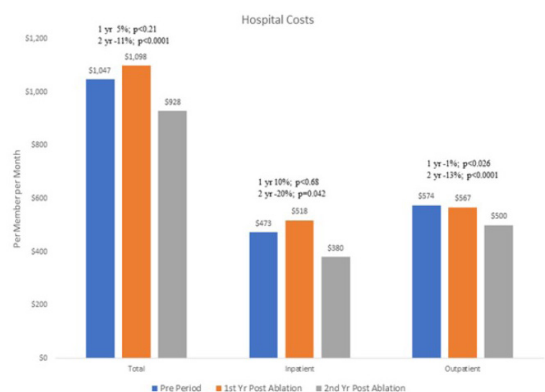


Figure 3: Change in hospital costs pre- and post-AF hybrid ablation. AF, atrial fibrillation.

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Please Click for Supplemental Tables

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