

Outcome and Treatment of Atrial Fibrillation in Obesity- Insights from the National Inpatient Sample Database

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Abstract

Background: Obesity is considered a significant risk factor for numerous cardiovascular conditions. The prevalence of atrial fibrillation (AF) is elevated among patients with obesity. Weight loss has been shown to reverse cardiac remodelling, leading to lower recurrence of AF despite the better prognosis in obese patients.

Methods: A retrospective cohort analysis using the Nationwide Inpatient Sample (2016–2019) identified adult patients hospitalized with AF. Patients were categorized by BMI using ICD-10 codes. The primary focus was on procedural outcomes (electrical cardioversion {ECV} and cardiac ablation {CA}), given the limitations of the NIS database in capturing pharmacologic data. Variables like comorbidities, demographic factors, and obesity-related complications were adjusted for in the analysis. Multivariate logistic regression adjusted for demographics, hospital factors, and comorbidities.

Results: The analysis included 1,625,809 weighted patients. Patients include underweight (6.66%), normal BMI (4.03), overweight (6.51%), obesity class I (20.65%), obesity class II (21.45%), and obesity class III (40.7).

After multivariate regression analysis, patients with obesity class I, II, or III had higher odds of ECV, irrespectively of coronary risk factors (OR 1.3, 95% CI 1.25-1.37, OR 1.3, 95% CI 1.32-1.43, OR 1.3, 95% CI 1.29-1.38, respectively, with statistically significant P values). However, underweight or normal BMI patients had fewer odds of ECV (OR 0.5 95%CI 0.49-0.61 and OR 0.6 95%CI 0.58-0.74, respectively, with P values <0.001). Meanwhile, there was no statistical significance between a BMI and the odds of CA.

Conclusion: Our study highlights the significant impact of obesity on AF management, as higher BMI increased the likelihood of ECV but not CA. Obesity complicates management through altered pharmacokinetics affecting anticoagulants and control strategies, with increased epicardial adipose tissue potentially worsening outcomes. Future research should explore epicardial adipose tissue (EAT) and treatment interventions in obesity-related AF.

Keywords: Atrial fibrillation, Obesity, Arrhythmia, Cardioversion, Cardiac ablation, Electrophysiology

Introduction

Obesity is a multifaceted health issue influenced by a complex interplay of biological, psychological, social, economic, and environmental factors. The pathways and mechanisms through which obesity leads to harmful health outcomes vary among individuals [1]. The WHO defines overweight and obesity as abnormal or excessive fat accumulation that poses health

risks [2]. Obesity is typically measured by BMI (weight in kg/height in m²), with a BMI ≥ 30 indicating obesity [3]. Globally, an estimated 39-49% of the population, or approximately 2.8-3.5 billion people, are affected by overweight or obesity [4]. The Global Burden of Disease (GBD) study highlights that high BMI caused around 4 million deaths in 2015, with over two-thirds linked to cardiovascular diseases (CVD) [5]. Among the increasing cardiovascular comorbidities associated with

obesity, atrial fibrillation (AF) stands out as the most prevalent sustained arrhythmia. The growing burden of AF is attributed to many factors, such as an aging population, increasing prevalence of obesity, enhanced detection methods, and improved survival rates given medical advancement [6,7].

Obesity increases blood volume, raising the workload of the left atrium (LA) and ventricle, leading to chamber dilation, hypertrophy, and diastolic dysfunction. These structural changes, along with electrical alterations, epicardial fat infiltration, and metabolic dysfunction, create a substrate for AF [8,9]. Neurohormonal dysregulation, oxidative stress, and ion channel changes further promote conduction abnormalities, shortening the refractory period and increasing ectopic activity, driving AF [10]. Notably, weight reduction has shown beneficial effects in improving AF outcomes, including a decreased risk of new-onset AF and recurrence following ablation. Bariatric surgery lowers the risk of new-onset AF and post-ablation recurrence while improving insulin resistance, blood pressure, and EAT volume [11]. Studies have shown that weight loss reduces LA EAT volume, myocardial fat infiltration, inflammation, and fibrosis, thereby improving atrial conduction and function [12].

Conversely, the “obesity paradox” suggests that overweight and obese AF patients may have lower cardiovascular and all-cause mortality, though findings remain inconsistent. While randomized trials support this paradox, observational studies vary in conclusions [13]. Nonetheless, evidence consistently demonstrates that weight loss reduces AF burden and reverses structural changes. The 2024 ESC guidelines recommend at least a 10% weight reduction to alleviate AF symptoms and burden [14].

While weight loss has been shown to reduce AF burden and improve ablation outcomes, there is a critical gap in understanding how obesity influences acute AF management, particularly the likelihood of undergoing electrical cardioversion or catheter ablation in hospitalized patients. This study addresses this gap by analyzing a large, nationally representative inpatient dataset to evaluate the association between BMI and procedural utilization in AF management. By providing insights into whether obesity influences treatment decisions and outcomes, this research aims to optimize AF management in obese patients, inform personalized risk stratification, and improve clinical decision-making, ultimately addressing the growing burden of AF in an increasingly obese population.

Methods

Study design and data source

We performed a retrospective cohort analysis using the Nationwide Inpatient Sample (NIS) database, focusing on data collected between 2016 and 2019. The National

Inpatient Sample (NIS) is a publicly available, all-payer inpatient database in the United States, created under the Healthcare Cost and Utilization Project (HCUP) and funded by the Agency for Healthcare Research and Quality (AHRQ). It provides a comprehensive, nationally representative dataset of hospitalizations, capturing over 7 million hospital stays annually, ensuring national representativeness, and making findings more generalizable by comparing outcomes across different hospitals and regions. Limitations of this study include the absence of clinical and echocardiographic data, which are crucial for guiding AF management. Additionally, the study lacks information on antiarrhythmic drug use before or during hospitalization, as well as the energy (joules) required for cardioversion, which may impact treatment outcomes.

Study population and variable definitions

Adult patients (n=1,625,809) hospitalized with a primary diagnosis of atrial fibrillation (AF) were identified using the International Classification of Diseases, Tenth Revision, Clinical Modification (ICD-10-CM) code I48. We identified patients who underwent electrical cardioversion in this cohort using the procedure code 5A2204Z, while we identified those undergoing cardiac ablation using the procedure codes 02583ZZ and 02584ZZ.

Patients were further stratified by BMI categories, determined using ICD-10-CM codes for obesity and BMI classification. Additional variables extracted included age, sex, race, median household income quartile, hospital teaching status, bed size, location, and region. Comorbidities such as hypertension, hyperlipidemia, tobacco use, type 1 diabetes mellitus (T1DM), type 2 diabetes mellitus (T2DM), chronic kidney disease (CKD), cerebrovascular disease/transient ischemic attack (TIA), chronic obstructive pulmonary disease (COPD), coronary artery disease (CAD), heart failure (HF), peripheral artery disease (PAD) and pulmonary embolism (PE) and overall severity of illness were assessed using the Charlson Comorbidity Index (CCI) score (**Table 1**).

Statistical analysis

Univariate and multivariate regression analyses were performed to analyze the impact of BMI on the likelihood of undergoing electrical cardioversion and or cardiac ablation among hospitalized AF patients. In this study, we compared continuous variables using the Student's t-test and categorical variables using the chi-squared test. We reported effect sizes as odds ratios (ORs) with 95% confidence intervals (CIs).

The study's primary outcome was establishing an association between BMI and the odds of successful electrical cardioversion or cardiac ablation. Statistical significance was defined as a two-sided P-value<0.05. All analyses accounted for the NIS's complex sampling design through appropriate weighting, stratification, and clustering using the Svy package in STATA version 17 (StataCorp LLC).

Table 1: Patients Characteristics.						
	Odds Ratio	std. err.	t	P> t	[95% conf. Interval]	
Age	0.9826277	0.000496	-34.72	0	0.981656	0.9836004
Female	0.7833023	0.0081718	-23.41	0	0.7674474	0.7994848
Race						
Black	0.6298378	0.013261	-21.96	0	0.6043738	0.6563746
Hispanic	0.6750921	0.0170468	-15.56	0	0.6424919	0.7093463
Asian/Pacific Islander	0.6097399	0.0299215	-10.08	0	0.5538228	0.6713027
Native American	0.9992759	0.0860962	-0.01	0.993	0.8439982	1.183121
Other	0.6785769	0.0281741	-9.34	0	0.62554	0.7361107
BMI						
Underweight (<18.5)	0.5540869	0.0295509	-11.07	0	0.4990886	0.615146
Normal (18.5–24.9)	0.6619993	0.0410568	-6.65	0	0.5862226	0.747571
Overweight (25–29.9)	1.064004	0.0410568	1.54	0.125	0.9830019	1.151681
Obese I (30–34.9)	1.312167	0.0291701	12.22	0	1.256218	1.370608
Obese II (35–39.9)	1.312167	0.0291701	15.22	0	1.321498	1.435009
Obese III (40–49.9)	1.341316	0.0222369	17.71	0	1.29843	1.385619
Hypertension	1.001349	0.0125604	0.11	0.914	0.9770293	1.026274
Hyperlipidemia	1.14816	0.011914	13.31	0	1.125044	1.171752
Tobacco	0.8010816	0.420212	-4.23	0	0.7228084	0.8878311
T1DM	0.9042846	0.0896585	-1.01	0.31	0.7445662	1.098264
T2DM	0.9813674	0.0124989	-1.48	0.14	0.9571714	1.006175
CKD	1.216187	0.0207079	11.49	0	1.176267	1.257462
TIA	0.8345	0.014753	-10.23	0	0.8060777	0.8639245
COPD	0.9397686	0.0141899	-4.11	0	0.9123624	0.9679981
CAD	1.066423	0.0126591	5.42	0	1.041896	1.091527
AFIB	0.7428396	0.0335206	-6.59	0	0.6799575	0.8115371
Heart Failure	1.737728	0.0224426	42.79	0	1.694291	1.78228
PAD	1.008146	0.027363	0.3	0.765	0.9559129	1.063232
PE	0.8595164	0.0531556	-2.45	0.014	0.7613929	0.9702855
Death	0.752385	0.0447199	-4.79	0	0.6696426	0.8453513
Abbreviations: BMI: Body Mass Index; T1DM: Type 1 Diabetes Mellites; T2DM: Type 2 Diabetes Mellites; CKD: Chronic Kidney Disease; TIA: Transient Ischemic Attack; COPD: Chronic Obstructive Pulmonary Disease; CAD: Coronary Artery Disease; AFIB: Atrial Fibrillation; PAD: Peripheral Artery Disease; PE: Pulmonary Embolism						

Results

A total of 1,625,809 patients admitted to hospitals with AF from 2016 to 2019 were identified. The mean age was 70.53 years, with Caucasians making up 80.65% of the cohort. Most hospitalizations occurred in urban areas (89.29%), distributed regionally across the South (40.49%), Midwest (23.77%), Northeast (20.28%), and West (15.46%). Medicare was the most

common insurance type (69.8%), followed by private insurers (20.6%). Patients were categorized by BMI as underweight (6.66%), normal BMI (4.03%), overweight (6.51%), obese class I (20.65%), obese class II (21.45%), and obese class III (40.7%).

In the cohort, 62,365 patients underwent cardiac ablation (3.84%), and 306,775 (18.87%) underwent electrical cardioversion. After adjusting for comorbidities, including

hypertension, hyperlipidemia, diabetes mellitus, CKD, cerebrovascular disease, COPD, CAD, HF, PAD, and PE, a higher BMI was significantly associated with increased odds of electrical cardioversion. Patients classified as obese class I, II, and III had adjusted odds ratios (OR) of 1.3 (95% CI 1.25–1.37), 1.3 (95% CI 1.32–1.43), and 1.3 (95% CI 1.29–1.38), respectively ($P<0.001$ for all). In contrast, underweight and normal BMI patients had lower odds of electrical cardioversion (OR 0.5, 95% CI 0.49–0.61 and OR 0.6, 95% CI 0.58–0.74, respectively; $P<0.001$ for both).

BMI was not significantly associated with outcomes across all categories in patients who underwent cardiac ablation. Underweight patients (OR 1.01, 95% CI 0.85-1.2, $p=0.85$), those with normal BMI (OR 0.81, 95% CI 0.64-1.02, $p=0.08$), and overweight patients (OR 1.05, 95% CI 0.89-1.23, $p=0.52$) showed no statistically significant differences. Similarly, obesity demonstrated no significant association, including

Class I (OR 0.99, 95% CI 0.91-1.09, $p=0.96$), Class II (OR 1.02, 95% CI 0.93-1.12, $p=0.56$), and Class III (OR 0.95, 95% CI 0.88-1.02, $p=0.17$).

No statistically significant correlation was observed between BMI and the likelihood of undergoing cardiac ablation (**Figure 1**).

Discussion

The prevalence of obesity and AF has been rising rapidly, with projections estimating that 78% of US adults will be overweight/obese and AF cases will reach 16 million by 2050. Obesity increases the risk of AF by 50%, highlighting the importance of weight management in preventing AF [15-17].

Our study showed that obesity classes I, II, and III had statistically increased odds of undergoing electrical

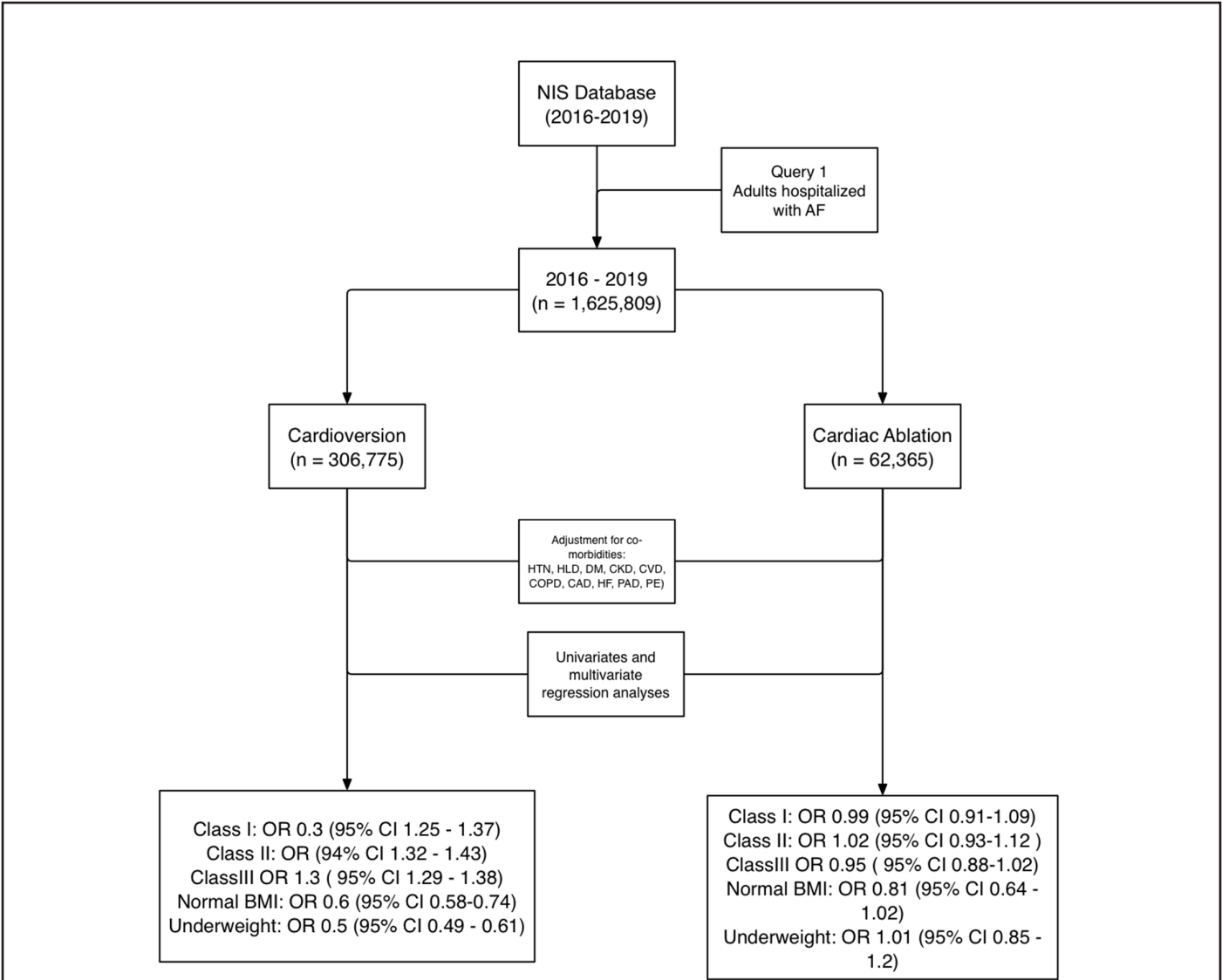


Figure 1. Flow Chart.

cardioversion in comparison to people with normal BMI or those who are underweight. The odds ratio for electrical cardioversion amongst people with obesity class I, II, and III was 1.3 (95% CI 1.25 – 1.37), 1.3 (95% CI 1.32 – 1.43), and 1.3 (95% CI 1.29 – 1.38), respectively ($P < 0.001$ for all). In contrast, the odds ratio for electrical cardioversion among subjects with normal BMI and underweight was 0.5 (95% CI 0.49 – 0.61) and 0.6 (95% CI 0.58 – 0.74), respectively; $P < 0.001$ for both. This can be explained as obesity leads to structural and electrical changes in the heart, including increased ectopic activity due to chamber dilation, hypertrophy, and metabolic dysfunction. These factors increase the arrhythmogenic burden, aligning with our findings that higher BMI was associated with increased odds of electrical cardioversion. Our study also found no statistically significant relationship between obesity and the likelihood of undergoing cardiac ablation. This suggests that BMI might impact the management of AF in hospital settings. Our study is unique in that it not only highlights that increased BMI is associated with increased occurrence of AF but also signifies the impact of BMI on the choice of management for AF. To the best of our knowledge, this is the first NIS study assessing the outcomes of AF in obese patients stratified on the basis of BMI and how it influences the management of AF.

Our study demonstrates that among the patients undergoing electrical cardioversion, the odds of AF were significantly higher among patients who were obese. The result was statistically significant among all the obesity classes (30% increased association among all classes). In contrast, the odds of AF were significantly lower among patients with normal BMI or underweight (50% lower in normal BMI and 40% lower in underweight patients). Prior studies have also reported similar findings. Wong *et al.*, in their meta-analysis involving 51 studies, noted that for every 5 kg/m² increase in BMI, the incidence of AF increases by 10-29% increased risk of incident, post-operative, and post-ablation AF [18]. Similarly, the HUNT3 study reported 18% and 59% increased AF risk among overweight and obese subjects, respectively [19]. A recently published meta-analysis by Folli *et al.* involving 50 studies reported an increased risk of newly diagnosed AF among overweight, obese, and morbidly obese patients and recurrent post-ablation AF among obese and morbidly obese patients [13]. This suggests that an increase in BMI is directly proportional to the risk of both new onset and recurrent AF.

The data regarding AF incidence and BMI is conflicting, with some studies reporting increased AF incidence with obesity and others supporting the hypothesis called the “obesity paradox”. As per the paradox, higher BMI is inversely associated with mortality rates in AF [20]. Rodriguez-Reyes *et al.* reported that high BMI and waist-hip ratio were associated with lower case fatality rates among AF patients [21]. Similarly, in the Gulf SAFE trial, AF patients with higher BMI had lower risks of stroke, bleeding, heart failure admission, and all-cause mortality [22]. A likely explanation for the lower all-cause mortality rates could be more aggressive treatment and management of comorbidities for obese patients. For example, the ARISTOTLE

trial showed that the use of statins and beta blockers was 50% and 68% for obese AF patients compared to 34% and 56% for non-obese AF patients [10]. Although these studies report the rate of complications, especially all cause of mortality is lesser during follow up periods, the rates of prevalence and post-ablation recurrence of AF still has a direct proportional relationship with BMI [10,22,23]. Hence, our article strengthens the weight reduction point to decrease the AF rates.

Ligero *et al.*, in their study, reported that increased BMI (≥ 25 kg/m²) was independently associated with an increased risk of recurrence of AF after initial intervention with electrical cardioversion [24]. This shows that BMI plays a role in AF recurrence. Interestingly, in our study, no significant association was observed between AF and obesity classes among patients undergoing cardiac ablation. This might indicate that BMI affects the treatment of AF. Patel *et al.*, in their study, reported increased failure rates of catheter ablation among obese patients [25]. Similarly, Chilukuri *et al.*, in their prospective study, reported an increase in BMI by one unit and increased the recurrence rates of AF by 11% after catheter ablation [26]. Moreover, catheter ablation can be technically more challenging in obese patients. Hence, electrical cardioversion might be tried first in patients with higher BMIs.

Our study has several limitations. First, the NIS database’s cross-sectional and administrative design limited the collection of patient-level information essential for classifying patient severity, such as laboratory, radiographic, and echocardiographic results. Furthermore, the identification of AF types, such as new onset or paroxysmal, was made more difficult by the errors in ICD-10 coding. In addition, the indication of choosing cardiac ablation and electrical cardioversion was not specified. Moreover, this study does not assess the long-term outcomes of AF and cannot comment on the recurrence rates of AF and whether or not it is associated with BMI. Furthermore, the database’s emphasis on in-hospital events raises the possibility of overlooking post-hospitalization outcomes, such as out-of-hospital sudden cardiac death, long-term mortality, and complications. Despite these limitations, our study has the advantage of being an extensive retrospective analysis with a good sample size and reporting AF association stratified based on BMI and classified based on cardiac intervention undertaken for the AF.

Conclusion

Our study highlights the significant impact of BMI on managing atrial fibrillation, particularly among patients undergoing electrical cardioversion. Obesity may affect treatment strategies and results in the management of AF, as patients in higher BMI categories (obesity classes I, II, and III) showed higher odds of undergoing ECV. Interestingly, BMI did not affect the probability of cardiac ablation, suggesting a more nuanced relationship between body weight and AF treatment options that needs more research. These results highlight the significance of tailored treatment plans with an emphasis on weight control to maximize results.

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Disclosures

None.

Author Contributions

Conceptualization: Allan, Archit, and Birgurman designed the study and developed the research idea. Methodology: Allan, Archit, and Birgurman were responsible for study design, data collection, and validation. Data Analysis & Interpretation: Allan performed statistical analysis and interpreted the results. Writing – Original Draft: Allan, Archit, Birgurman, Olayiwola, and Junaid drafted the manuscript. Writing – Review & Editing: Nirmal Kaur revised the manuscript and approved the final version. Supervision: Nirmal Kaur provided oversight and guidance throughout the study.

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