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ORIGINAL RESEARCH

Utilization and Complications of Catheter Ablation for Atrial Fibrillation in Patients With Hypertrophic Cardiomyopathy

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BACKGROUND: Atrial fibrillation (AF) is common and bears a major clinical impact in patients with hypertrophic cardiomyopathy (HCM). We aimed to investigate the use and real-world safety of catheter ablation for AF in patients with HCM.

METHODS AND RESULTS: We drew data from the US National Inpatient Sample to identify cases of AF ablation in HCM patients between 2003 and 2015. Sociodemographic and clinical data were collected, and incidence of catheter ablation complications, mortality, and length of stay were analyzed, including trends between the early (2003–2008) and later (2009–2015) study years. Among a weighted total of 1563 catheter ablation cases in patients with HCM, the median age was 62 (interquartile range, 52–72), 832 (53.2%) were male, and 1150 (73.6%) were white. The average annual volume of AF ablations in patients with HCM doubled between the early and the later study period (79–156). At least 1 complication occurred in 16.1% of cases, and the in-hospital mortality rate was 1%. Cardiac and pericardial complications declined from 8.8% to 2.3% and from 2.8% to 0.9%, respectively, between the early and the later study years ($P<0.01$). Independent predictors of complications included female sex (odds ratio [OR], 4.81; 95% CI, 2.72–8.51), diabetes mellitus (OR, 6.57; 95% CI, 2.68–16.09) and obesity (OR, 3.82; 95% CI, 1.61–9.06).

CONCLUSIONS: Despite some decline in procedural complications over the years, catheter ablation for AF is still associated with a relatively high periprocedural morbidity and even mortality in patients with HCM. This emphasizes the importance of careful clinical consideration, by an experienced electrophysiologist, in referring patients with HCM for an AF ablation.

Key Words: atrial fibrillation ■ catheter ablation ■ hypertrophic cardiomyopathy

Atrial fibrillation (AF) is the most common sustained arrhythmia in the general adult population, with a 4- to 6-fold higher prevalence and major clinical impact in patients with hypertrophic cardiomyopathy (HCM).[1–6] AF is associated with significant morbidity in patients with HCM, including increased risk of stroke and worsening of heart failure symptoms, as well as increased mortality, especially in patients with outflow obstruction.[5,7,8]

On top of the known morbidity associated with AF in the general population, loss of atrial kick in a noncompliant hypertrophic ventricle and rapid ventricular rates may have hemodynamic implications, aggravating left ventricular outflow tract obstruction and triggering symptoms of low cardiac output.[3,9] Therefore, preventing AF is a significant therapeutic goal in patients with HCM, but the current antiarrhythmic drug options are limited by potential safety concerns, side effects, and relatively low efficacy in patients with HCM.[10–13]

Use of catheter ablation (CA) for treatment of drug-resistant AF has dramatically increased over the past 2 decades.[14,15] In the general population, CA provides superiority in rhythm and symptom control compared with antiarrhythmic drug therapy[16–18] and even a mortality benefit in certain populations.[19–21]

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CLINICAL PERSPECTIVE

What Is New?

- This is the first large-scale, real-world study to analyze the complication rate for catheter ablation of atrial fibrillation in patients with hypertrophic cardiomyopathy.
- Despite some decline in procedural complications during the recent years, atrial fibrillation ablation is still associated with a relatively high periprocedural morbidity (16.1%) and even mortality (1%) in patients with hypertrophic cardiomyopathy.

What Are the Clinical Implications?

- Our study results emphasize the importance of careful clinical consideration, by an experienced electrophysiologist, when referring patients with hypertrophic cardiomyopathy for an atrial fibrillation ablation.

Nonstandard Abbreviations and Acronyms

AF	atrial fibrillation
CA	catheter ablation
CCI	Charlson Comorbidity Index
HCM	hypertrophic cardiomyopathy
ICD-9-CM	*International Classification of Diseases, Ninth Revision, Clinical Modification*
NIS	National Inpatient Sample
OR	odds ratio

Several previous small reports, including a recent meta-analysis, investigated CAs in patient with HCM, showing relatively low efficacy in preventing AF recurrence, increased need for repeat procedures, and long-term antiarrhythmic drug therapy to maintain sinus rhythm.[3,22–24] The evidence for ablation procedure safety, reported from several small studies, mostly from experienced, high-volume medical centers was inconsistent, with substantial heterogeneity between the centers.[3,22–24]

We sought to investigate the nationwide trends in use of CA for AF in patients with HCM and analyze incidence and predictors of periprocedural complications of the ablation procedure, using the National Inpatient Sample (NIS) data set.

METHODS

The national database data used for this study, analytic methods, and study materials will not be made available to other researchers for purposes of reproducing the results or replicating the procedure because of restrictions on the sharing of data in the Healthcare Cost and Utilization Project Data Use Agreement. The NIS database is publicly available for purchase, and the transparent and detailed methods that we have described make it possible for anyone who wishes to do so to replicate this study and reproduce our results.

Data Source

The data were drawn from the National Inpatient Sample, the Healthcare Cost and Utilization Project, and Agency for Healthcare Research and Quality.[25,26] The NIS is the largest collection of all-payer data on inpatient hospitalizations in the United States. The data set represents an approximate 20% stratified sample of all inpatient discharges from US hospitals. This information includes patient-level and hospital-level factors: patient demographic characteristics, primary and secondary diagnoses and procedures, Agency for Healthcare Research and Quality comorbidities, length of stay, hospital region, hospital teaching status, hospital bed size, and cost of hospitalization. National estimates can be calculated using the patient-level and hospital-level sampling weights that are provided by NIS. For the purpose of this study, we obtained data for the years 2003 to 2015. Of note, *International Classification of Diseases, Tenth Revision* (*ICD-10-CM*) coding was introduced in the last quarter of 2015. For this reason, and to avoid any possible cross-coding issues during the translation, we included only the first 3 quarters of 2015. All NIS data sets include deidentified data; therefore, this study was deemed exempt from institutional review by the Human Research Committee. Additional detailed information regarding the NIS database design have been summarized in Data S1.

Study Population and Variables

International Classification of Diseases, Ninth Revision, Clinical Modification (*ICD-9-CM*) was used for reporting diagnoses and procedures in the NIS database during the study period. For each index hospitalization, the database provides a principal discharge diagnosis and a maximum of 14 or 24 additional diagnoses (depending on the year), in addition to a maximum of 15 procedures. We identified patients 18 years of age or older with a diagnosis of hypertrophic cardiomyopathy based on *ICD-9-CM* codes (ie, 425.11 for obstructive HCM or 425.18 for nonobstructive HCM). Within this population we sought patients who had a diagnosis of AF (*ICD-9-CM* code 427.31) and underwent a CA procedure (*ICD-9-CM* code 37.34) during 2003 to 2015. To avoid selection bias and choose only the patient who had an ablation for AF, we have excluded all the patients with

other arrhythmias or potential reasons for an ablation like atrial flutter (427.32), supraventricular tachycardia (codes: 427.0, 427.89, 426.7, and 426.89), ventricular tachycardia (427.1), Wolff-Parkinson-White syndrome (426.7), "other premature beats" (427.69), and cardiac dysrhythmia (427.89). Furthermore, we excluded patients with either of the following cardiac procedures during the index hospitalization, to avoid attributing their complications to the ablation procedure; (1) pacemaker implantation (00.50, 00.52, 00.53, 37.71–37.79) or (2) implantable cardioverter defibrillator insertion (37.94–37.98, 00.51, 00.54).

The following patient demographics were collected from the database; age, sex, and race. Associated comorbidities were identified by measures from the Agency for Healthcare Research and Quality. For the purposes of calculating Deyo-Charlson Comorbidity Index (Deyo-CCI), an additional list of comorbidities was identified from the database using *ICD-9-CM* codes (Table S1.). Deyo-CCI is a modification of the CCI, containing 17 comorbid conditions. Higher Deyo-CCI indicates a more severe condition and is an indicator of patient mortality 1 year after admission.[27]

Study Outcomes

We identified the common in-hospital complications of CAs using the *ICD-9-CM* diagnosis and procedure codes using the same methodology as described in our prior publication regarding the wide range of CAs in the general population.[14] These complication include (1) cardiac complications (postoperative cardiac block, myocardial infarction, cardiac arrest, congestive heart failure, and others); (2) pericardial complications (tamponade, hemopericardium, pericarditis, and pericardiocentesis); (3) vascular complications (arteriovenous fistula, blood vessel injury, accidental puncture, injury to the retroperitoneum, vascular complications requiring surgery, and other iatrogenic vascular complications); (4) postoperative hemorrhage or hematoma (including postoperative hemorrhage requiring blood transfusion); (5) postoperative stroke/transient ischemic attack; (6) pneumothorax or hemothorax; (7) diaphragm paralysis; (8) infections (fever, septicemia, and postprocedural aspiration pneumonia); and (9) in-hospital deaths. All codes used in identifying complications are summarized in Table S2.

Because of restrictions placed by the Healthcare Cost and Utilization Project on analyzing and presenting infrequent events (<5), to avoid potential identification of the patients involved, and the small expected number of individual comorbidities or complication types per year, we decided to present the trends in baseline characteristics and complications between combined early (2003–2008) versus late (2009–2015) study periods. The US Food and Drug Administration approval of new technologies including contact force sensing and the cryoballoon ablation system in 2009 and 2010, with potential safety benefits, added some clinical interest to this division.

Statistical Analysis

Trend weight files provided by Agency for Healthcare Research and Quality were used to reflect national estimates. The chi-squared test and Wilcoxon rank-sum test were used to compare categorical variables and continuous variables, respectively.

To account for hospital-level clustering of discharges, we generated a two-level mixed-effects logistic regression model in order to identify independent predictors of complications. Congruent with Healthcare Cost and Utilization Project NIS design, hospital identification number was employed as a random effect with patient-level factors clustered within hospital-level factors. Candidate variables included patient-level characteristics, Deyo-CCI and hospital-level factors. For all analyses, we used SAS software version 9.4 (SAS Institute Inc., Cary, NC). A P value <0.05 was considered significant.

RESULTS

Of 98 754 774 unweighted hospitalizations from January 2003 to September 2015, a total of 322 hospitalizations were included in the analysis based on the inclusion/exclusion criteria described above. After implementing the weighting method, these represented an estimated total of 1563 hospitalizations for AF ablation in patients with HCM during the study period. The annual number of ablations almost doubled from 79 on average during the "early years" (2003–2008) to 156 annual procedures on average during the "late years" (2009–2015) of the study. The percentage of ablations performed in teaching hospitals increased from 76.7% to 87.9% between the study periods (P<0.0001).

Baseline characteristics and comorbidities

Demographic and clinical characteristics of the study population are presented in Table 1. The median age was 62 (52–72) years, with almost 21% of the patients being over 75 years old. Fifty-five percent of the patients suffered from hypertension, 18% had chronic obstructive pulmonary disease, 15.3% had diabetes mellitus, 11.5% swere obese, and 10% had renal failure.

Comparing between the early and late study periods reveals male predominance in the later years

Table 1. Baseline Characteristics of the Study Population

	Total	2003–2008	2009–2015*	*P* Value
AF ablation, n				
Unweighted	322	100	222	
Weighted	1563	475	1089	
Age group, %				0.0003
18–44y	11.5	14.7	10.1	
45–59y	34.4	29.8	36.4	
60–74y	33.0	32.4	33.3	
≥75y	20.8	22.2	20.2	
Missing	0.3	0.9	0.0	
Sex, %				0.0320
Male	53.2	49.1	55.0	
Female	46.8	50.9	45.0	
Race, %				<0.0001
White	73.6	64.9	77.4	
Nonwhite	9.0	6.2	10.1	
Other/missing	17.4	28.8	12.5	
Comorbidity, %				
Hypertension	55.5	52.7	56.8	0.1416
Chronic pulmonary disease	18.0	19.4	17.3	0.3210
Diabetes mellitus	15.3	11.0	17.2	0.0017
Obesity	11.5	8.1	13.0	0.0045
Renal failure	10.0	4.8	12.3	<0.0001
Peripheral vascular disorders	4.3	4.0	4.5	0.6322
Deyo-CCI, %				<0.0001
0	40.8	43.6	39.5	
1	23.9	30.1	21.2	
≥2	35.3	26.3	39.3	
Primary payer, %				0.0755
Medicare	45.1	43.4	45.8	
Private insurance	44.2	47.1	43.0	
Medicaid	7.0	7.5	6.8	
Self-pay	0.6	0.0	0.9	
Other/missing	3.1	2.0	3.5	
Hospital status, %				<0.0001
Urban teaching	84.5	76.7	87.9	
Urban nonteaching	14.5	22.2	11.2	
Rural	0.6	1.0	0.5	
Missing	0.4	0.0	0.5	
Hospital region, %				<0.0001
South	34.3	40.0	31.7	
Northeast	26.7	17.9	30.5	
Midwest	22.2	15.1	25.3	
West	16.9	26.9	12.5	
Hospital bed size, %				0.0361
Large	83.3	86.5	81.9	
Small/Medium	16.4	13.5	17.6	
Missing	0.4	0.0	0.5	

P-values were generated using the chi-square test and refer to changes in frequency before and after 2009. AF indicates atrial fibrillation; and CCI, Charlson Comorbidity Index.

*Analysis of 2015 data was done for only the first 3 yearly quarters (January 1, 2015, to September 30, 2015).

(49.1% versus 55%; *P*=0.03) as well as a significant increase in the individual comorbidity prevalence, including obesity (8.1% versus 13%, *P*=0.0045), diabetes mellitus (11% versus 17.2%, *P*=0.0017), and renal failure (4.8% versus 12.3%, *P*<0.0001). Accordingly, a Deyo-CCI of ≥2 was more prevalent in the later study years (39.3% versus 26.3%).

In-Hospital Course

At least 1 complication occurred in 16.1% of the 1563 ablation procedures during the study period. All cause, in-hospital mortality was documented in 1% of the cases, and the mean length of hospitalization was 4.7±0.38 days. Total and specific prevalence of the complications for all patients as well as per study period (early versus late) are elaborated in Table 2. The most common complication during the study period was hemorrhage (6.9%), followed by cardiac complications (4.3%). Interestingly, the percentage of patients who required blood transfusion was also relatively high for a venous procedure (2.6%).

The data demonstrate a significant decrease in complication rates during the later study period (20.9% versus 14.0%, *P*=0.001). Both cardiac and pericardial complication rates dropped significantly between the early and later study period, 8.8% versus 2.3% (*P*<0.001) and 2.8% versus 0.9% (*P*=0.006), respectively.

Predictors of In-Hospital Complications

Table 3 presents the baseline characteristics of patients who did and did not suffer from at least 1 complication during the hospitalization. Female sex was more prevalent among patients who suffered from complications (57.5% versus 44.8%; *P*=0.0002) as well as diabetes mellitus (25% versus 13.5%, *P*<0.0001) and obesity (15.5% versus 10.8%, *P*=0.03). More of these patients were Medicare beneficiaries (51.2% versus 43.9%; *P*<0.0001).

The multivariate analysis for predictors of in-hospital complications during hospitalization for AF ablation

Table 2. Total and Specific Complications Rate During the Study Period

Complication	Year			
	Total	2003–2008	2009–2015	*P* Value
AF ablation: unweighted, n	322	100	222	
AF ablation: weighted, n (100%)	1563	475	1089	
At least 1 complication, %	16.1	20.9	14.0	0.0006
Hemorrhage, %	6.9	8.2	6.3	0.1534
Cardiac, %	4.3	8.8	2.3	<0.0001
Infection, %	3.5	4.3	3.2	0.2470
Pulmonary, %	3.5	4.1	3.2	0.3852
Vascular, %	1.8	1.8	1.8	0.9844
Pericardial, %	1.5	2.8	0.9	0.0059
Neurological, %	0.6	1.0	0.5	0.2003
Diaphragmatic paralysis, %	0.0	0.0	0.0	N/A
Length of stay (days), mean±SEM	4.74±0.38	6.44±0.83	4.01±0.38	<0.0001

Analysis of 2015 data was done for only the first 3 yearly quarters (January 1, 2015, to September 30, 2015). *P* values refer to changes in complication frequency before and after 2009. *P* value for length of stay was calculated using the Wilcoxon 2-sample test. For all other variables, the chi-square test was used. AF indicates atrial fibrillation; and N/A, not applicable.

is presented in Table 4. Female sex (odds ratio [OR], 4.81; 95% CI, 2.72–8.51), diabetes mellitus (OR, 6.57; 95% CI, 2.68–16.09), and obesity (OR, 3.82; 95% CI, 1.61–9.06) were strong independent predictors of complications. Interestingly, there was a trend toward a higher complication rate in 45- to 59-year-old patients (OR, 2.55; 95% CI, 0.96–6.8). White patients had significantly increased ORs for complications in a multivariate analysis, but it is important to notice that the race data were missing in some 17.4% of the patients. Despite a significant decrease in complication rate in recent years, study period (early versus late) was not an independent predictor of complications in this study.

DISCUSSION

Using data from the NIS, the largest all-payer inpatient database in the United States, we identified a weighted total of 1563 patients with HCM who underwent ablation for AF. There was a dramatic increase in the volume of AF ablation procedures performed in this population in the United States between 2003 and 2015. A high complication rate of 16%, including 1% mortality, was documented in patients with HCM during the study period. Interestingly, despite a rising prevalence of comorbidities like obesity, diabetes mellitus, and renal failure, we documented a decline from 20.9% to 14% in complication rate in the recent years, still being alarmingly high. These data regarding the safety, together with the body of evidence regarding lower efficacy of AF ablation in HCM patients, compared with the general population, emphasize the importance of careful clinical judgment in referring a patient with HCM for AF ablation.

The patient population in prior reports on AF ablation in HCM patients was relatively small, with up to a few dozen patients, usually from a single medical center.[22,28–30] This study presents first nationwide, real-world experience, analyzing a weighted total of 1563 AF ablation hospitalizations in patients with HCM. The clinical characteristics of the patient population in this study were consistent with prior reports on AF ablation in patients with HCM in regards to the different comorbidities.[28–30] Albeit, we had higher representation of women, close to 47%, compared with suboptimal representation (usually <30%[22]) in prior studies.

Many of the prior publications on AF ablation in HCM patient population did not report detailed complication rates and concentrated on the ablation efficacy.[24,28–30] Bassiouny et al[31] showed a complication rate of 9% in 79 patients with HCM who underwent AF ablation at the Cleveland Clinic. In a more recent meta-analysis of the AF CA outcome in patients with HCM, Zhao et al[22] also acknowledged that periprocedural complication reporting was heterogeneous, and calculated a 5.1% (95% CI, 2.8–9.6%) pooled complication rate across the examined studies. The complication rate found in our study was considerably higher (16.1%) for the entire study period. One possible explanation for the higher complications rate in this report is the fact that it presents nationwide, real-world experience, in contrast to results from a single, many times large academic center with highly experienced operators.[31,32] Another possible explanation for increased complication rate is the higher proportion of female patients in our study. Compared with a prevalence of about 30% in the prior reports, 46.7% of the patients in our study were women, known to suffer from significantly higher complication rates during ablation procedures,[14,33] possibly attributable to lower cardiac mass and higher risk for perforation and pericardial complications.

Of notice, the complication rate decreased significantly, despite increased prevalence of different comorbidities, during the later study years. This decline occurred in parallel to increasing male-to-female ratio during these years (Table 1). The lower incidence of complications in males, together with improved experience with AF ablation procedure and the introduction of novel technologies like contact force sensing and cryoballoon ablation catheters could contribute to the lower complication rate in the later study years.

Table 3. Baseline Characteristics of Patients With and Without Any Complications During the Study Period

	Total	At Least 1 Complication	No Complications	*P* Value
AF ablation, n				
Unweighted	322	52	270	
Weighted	1563	252	1311	
Age group, %				0.0678
18–44y	11.5	8.0	12.2	
45–59y	34.4	30.6	35.1	
60–74y	33.0	38.5	32.0	
≥75y	20.8	22.9	20.4	
Missing	0.3	0.0	0.3	
Sex, %				0.0002
Male	53.2	42.5	55.2	
Female	46.8	57.5	44.8	
Race, %				<0.0001
White	73.6	85.3	71.4	
Non-white	9.0	4.1	9.9	
Other/missing	17.4	10.6	18.7	
Comorbidity, %				
Hypertension	55.5	59.5	54.8	0.1677
Chronic pulmonary disease	18.0	21.7	17.3	0.0942
Diabetes mellitus	15.3	25.0	13.5	<0.0001
Obesity	11.5	15.5	10.8	0.0308
Renal failure	10.0	6.0	10.8	0.0194
Peripheral vascular disorders	4.3	3.7	4.4	0.6072
Deyo-CCI, %				<0.0001
0	40.8	27.1	43.4	
1	23.9	29.9	22.8	
≥2	35.3	43.0	33.8	
Primary payer, %				<0.0001
Medicare	45.1	51.2	43.9	
Private insurance	44.2	34.7	46.1	
Medicaid	7.0	6.5	7.1	
Self-pay	0.6	2.0	0.3	
Other/missing	3.1	5.6	2.6	
Hospital status, %				0.1693
Urban teaching	84.5	82.4	84.9	
Urban nonteaching	14.5	17.6	13.9	
Rural	0.6	0.0	0.8	
Missing	0.4	0.0	0.4	
Hospital region, %				<0.0001
South	34.3	25.9	35.9	
Northeast	26.7	35.8	24.9	
Midwest	22.2	15.5	23.5	
West	16.9	22.8	15.8	
Hospital bed size, %				0.1144
Large	83.3	79.7	83.9	
Small/medium	16.4	20.3	15.6	
Missing	0.4	0.0	0.4	

P values refer to difference between "at least 1 complication" and "no complications." AF indicates atrial fibrillation; and CCI, Charlson Comorbidity Index.

Interestingly, we can compare the complication rate in this report to our group's prior study on CAs in general population, from the same NIS database, using the same methodology.[14] In our prior report, the complication rate for AF ablation in the general population was 7.2%, compared with a more than twice higher rate of 16.1% in this report for patients with HCM. As to the contemporary randomized clinical trials, the complication rates in the recently published CABANA (Catheter Ablation Versus Anti-Arrhythmic Drug Therapy for Atrial Fibrillation) trial were also significantly lower and stood at 3.9% for ablation catheter insertion-related complications, 1.2% for complications related to catheter manipulation within the heart, and 1.8% for ablation-related events, all lower than the numbers recorded for

Table 4. Multivariate Analysis of Predictors for In-Hospital Complications in Patients With Hypertrophic Cardiomyopathy Who Underwent an AF Ablation Between 2003 and 2015*

Predictor	Odds Ratio (95% CI)	*P* Value
Age group, y		0.059†
18–44 y	1.00 (reference)	N/A
45–59 y	2.55 (0.96–6.80)	0.060‡
60–74 y	1.95 (0.66–5.77)	0.222‡
≥75 y	0.74 (0.22–2.48)	0.615‡
Sex		<0.001†
Male	1.00 (reference)	N/A
Female	4.81 (2.72–8.51)	<0.001‡
Race		0.048†
Nonwhite	1.00 (reference)	N/A
White	3.12 (1.01–9.69)	0.048‡
Diabetes mellitus		<0.001†
No	1.00 (reference)	N/A
Yes	6.57 (2.68–16.09)	<0.001‡
Obesity		0.003†
No	1.00 (reference)	N/A
Yes	3.82 (1.61–9.06)	0.003‡

Complications are defined as "at least 1 complication." AF indicates atrial fibrillation; and N/A, not applicable.

*All variables are adjusted for sex, race, and yearly period.

†Global null hypothesis of no difference between the subgroups.

‡Pairwise comparison of each subgroup with the reference subgroup.

the HCM population.[34] Importantly, these data cannot be compared head to head without adjusting for the possible differences in the population characteristics. Additional studies will be needed to directly compare the patient populations and determine the reasons for the high complication rates in patients with HCM undergoing AF ablation.

Importantly, the current body of evidence regarding the efficacy of AF ablation in patients with HCM points out a high AF recurrence rate, as well as increased need for repeat procedures and long-term antiarrhythmic drug therapy to maintain sinus rhythm.[3,22–24] These data on relatively low efficacy, together with the safety concerns raised by our results, emphasize the importance of careful clinical consideration before referring patients with HCM for an AF ablation.

Study Limitations

First, the NIS database is retrospective administrative database and as such is susceptible to coding errors. This is an observational, noncontrolled cohort study, and no conclusions on causality can be drawn from these results. Complication rates derived from large databases should be interpreted with caution because they depend on reports from individual institutions, and reporting may not be consistent across different institutions. Second, we were unable to capture complications that occurred after hospital discharge. As a result, atrio-esophageal fistula and pulmonary vein stenosis were not accounted for because they typically occur after discharge. In addition, we could not reliably exclude patients who underwent atrioventricular node ablation to control the rate of their AF. Given that atrioventricular node ablation has a substantially lower risk compared with pulmonary vein isolation ablation, being a simple, short procedure without the need of general anesthesia, the potential complication rate for pulmonary vein isolation ablation can be even higher. Also, data about type of AF (ie, paroxysmal or persistent), procedural techniques, medications including anticoagulation management, imaging techniques and fluoroscopy time were unavailable. Finally, the in-hospital mortality cause in the study population cannot be determined and can theoretically be unrelated to the ablation procedure. These limitations are counterbalanced by the real-world, nationwide nature of the data, lack of selection bias, and absence of reporting bias introduced by selective publication of results from specialized centers.

CONCLUSIONS

Despite some decline in procedural complications over the years, CA for AF is still associated with a relatively high periprocedural morbidity and even mortality in patients with HCM. The concerns over procedural safety in these patients, along with the low efficacy shown in prior studies, emphasize the importance of careful clinical consideration by an experienced electrophysiologist in referring patients with HCM for an AF ablation.

ARTICLE INFORMATION

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Disclosures

None.

Supplementary Materials

Data S1
Tables S1–S2

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Supplemental Material

Data S1.

Supplemental Methods

The “unweighted group” is a 20% stratified sample of inpatient discharges from US hospitals, statistically representing the total “weighted” discharged population. The NIS sampling frame includes data from 47 statewide data organizations, covering more than 97% of the US population. The annual sample encompasses approximately 8 million discharges, which represent 20% of inpatient hospitalizations across different hospital types and geographic regions. The national estimates of the entire US hospitalized population are calculated using a standardized sampling and weighting method provided by the HCUP. The NIS dataset has been validated and used extensively over the years to accurately assess national trends in the utilization, disparities, and outcomes in various fields of medicine.

Table S1. ICD-9 Codes used to calculate the Deyo Comorbidity index.

ICD-9 CM codes	Condition	Score
410 – 410.9	Myocardial infarction	1
428 – 428.9	Congestive heart failure	1
433.9, 441 – 441.9, 785.4, V43.4	Peripheral vascular disease	1
430 – 438	Cerebrovascular disease	1
290 – 290.9	Dementia	1
490 – 496, 500 – 505, 506.4	Chronic pulmonary disease	1
710.0, 710.1, 710.4, 714.0 – 714.2, 714.81, 725	Rheumatologic disease	1
531 – 534.9	Peptic ulcer disease	1
571.2, 571.5, 571.6, 571.4 – 571.49	Mild liver disease	1
250 – 250.3, 250.7	Diabetes	1
250.4 – 250.6	Diabetes with chronic complications	2
344.1, 342 – 342.9	Hemiplegia or paraplegia	2
582 – 582.9, 583 – 583.7, 585, 586, 588 – 588.9	Renal disease	2
140-172.9, 174-195.8, 200-208.9	Any malignancy including leukemia and lymphoma	2
572.2 – 572.8	Moderate or severe liver disease	3
196-199.1	Metastatic solid tumor	6
042 – 044.9	Acquired Immunodeficiency syndrome (AIDS)	6

Table S2. ICD-9 codes for procedural complications used in the study.

Complication	ICD-9-CM Code(s)
Hemorrhage/Hematoma	
Hemorrhage/hematoma complicating a procedure	998.11-998.12
Acute post-hemorrhagic anemia	285.1
Hemorrhage requiring transfusion	(998.11-998.12, 285.1) AND (99.01-99.09)
Cardiac (including postoperative cardiac block, myocardial infarction, cardiac arrest, congestive heart failure and others)	997.1
Pericardial	
Hemopericardium	423.0
Tamponade	423.3
Pericardiocentesis	37.0
Acute pericarditis	420.90
Pulmonary	
Pneumothorax/hemothorax	512.1-512.2, 511.8
Diaphragm paralysis	519.4
Post-operative Respiratory Failure	518.51, 518.53
Other iatrogenic Respiratory Complications	997.3
Vascular	
Accidental puncture or laceration during a procedure	998.2, e8700-e709
Injury to blood vessels	900-904
Arteriovenous Fistula	447
Injury to retroperitoneum	8680.4
Vascular complication requiring surgical repair	39.31, 39.41, 39.49, 39.52, 39.53, 39.56, 39.57, 39.58, 39.59, 39.79
Other vascular complications	997.2, 997.7
Infection	
Fever	780.60, 780.62
Septicemia	038.*, 995.91-995.92, 998.02, 790.7
Post-procedural aspiration pneumonia	997.32
Neurological	
Nervous system complication, unspecified	997.00
Central nervous system complication	997.01
Iatrogenic cerebrovascular infarction or hemorrhage	997.02
Transient ischemic attack	435.9