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Catheter Ablation for Hospitalized Atrial FibrillationPatients with Reduced Systolic Function:Analysis of Inpatient Mortality, Resource Utilization and Complications

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Abstract

Background: Randomized trials have shown improvement in hard clinical end points when catheter ablation (CA) is employed as a management strategy for certain atrial fibrillation (AF) patients with heart failure and reduced ejection fraction (HFrEF). Limited data, however, exist in this realm outside the controlled clinical trial settings. We sought to determine real-world data on mortality and complications after utilization of CA in such patients.

Methods and Results: Data were derived from National Inpatient Sample from January 2008 to August 2015. Patients were identified using the International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM) codes. Baseline characteristics and outcomes were compared among HFrEF and AF patients undergoing CA or not. Propensity matching was done to mitigate selection bias and balance confounding variables. Various CA related complications were assessed. Logistic regression was done to determine predictors of mortality in our study cohort. A total of 2,569,919 patients were analyzed and a total of 7773 patients underwent CA. Mortality was significantly better in CA group in both unmatched (1.2% vs. 4.9%, $p < 0.01$) and propensity matched cohorts (1.2% vs. 3.6%, $p < 0.01$). Overall complication rate was 10.2% in CA cohort and primarily driven by cardiac and neurological etiologies. In regression analysis, CA remained a strong predictor of reduced mortality (OR 0.301, 95% CI 0.184-0.494).

Conclusion: CA is associated with improved mortality in admitted AF patients with concomitant HFrEF. Overall complication rate after CA was modest at 10.2%.Consideration can be given to the utilization of this therapeutic modality in hospitalized AF patients with concomitant HFrEF.

Introduction

Atrial fibrillation (AF) is the most common sustained arrhythmia encountered in clinical practice [1]. AF and congestive heart failure (CHF) frequently co-exist due to similar predisposing risk factors and ability of one to perpetuate the other [2,3]. AF is associated with increased CHF hospitalizations, stroke and all-cause mortality [4,5,6]. Various randomized trials conducted in last two decades have shown efficacy of catheter ablation (CA) for AF in HF and reduced ejection fraction (HFrEF) patients with respect to hard clinical endpoints of mortality and CHF hospitalizations [7,8]. With the result of these trials, it is expected that the volume of CA would continue to grow for management of AF and HFrEF patients. It is therefore imperative that data be sought from real world settings with respect to mortality and complications associated with CA in AF and HFrEF patients. Till to date, studies utilizing national databases for assessing aforementioned outcomes did not discriminate based on HF status of the patient [9,10,11,12]. We, therefore, utilized National Inpatient Sample (NIS) to assess contemporary trends in mortality and complications associated with CA in AF and HFrEF patients.

Key Words

Atrial fibrillation; Heart failure with reduced ejection fraction; Catheter ablation; Outcomes; National sample

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Methods

We conducted analysis on National Inpatient Sample (NIS)from January 2008 to August 2015. NIS is part of Healthcare Resource and Utilization Project (HCUP) and made possible by a Federal-State-Industry partnership sponsored by the Agency for Healthcare Research and Quality (AHRQ). The NIS is derived from all States and utilized for computing national estimates of healthcare utilization, cost and outcome [13]. NIS is compiled annually and the data can be used for analysis of disease trends overtime. Institutional Review Board approval and informed consents were not required for this study given the de-identified nature of the NIS dataset and

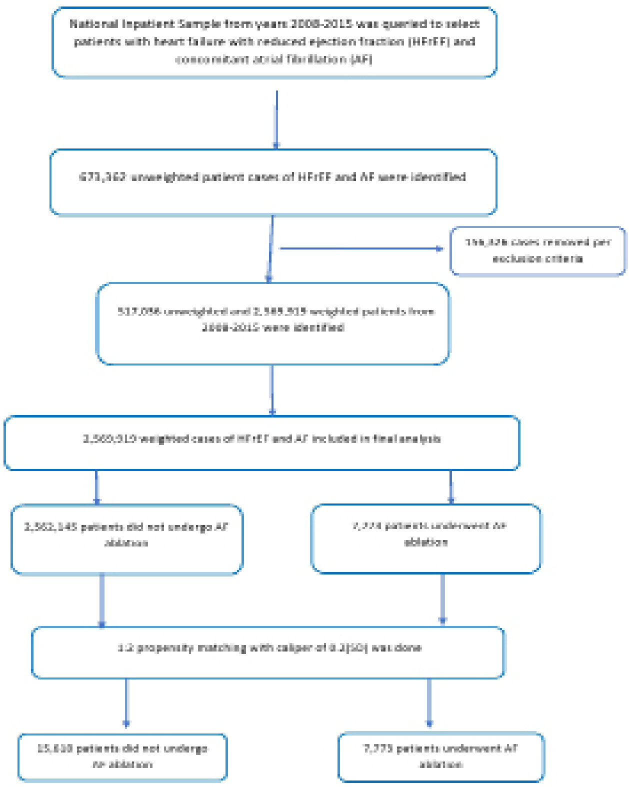

Figure 1: **Flow sheet of patient selection.**

public availability.

We analyzed NIS data from January 2008 to August 2015 using the International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM) codes. Patient under 18 years of age were excluded. Inclusion criteria included patients with HFrEF and AF. Cases with concurrent diagnostic codes for atrial flutter, supraventricular tachycardia, ventricular tachycardia, other premature beats, cardiac dysrhythmia, Wolf-Parkinson-White syndrome, atrioventricular nodal tachycardia and open surgical ablation were excluded. Age was divided into three groups, <65, 65-74 and ≥75. $CHAD_2VASC_2$ score was calculated. Complications associated with ablation were subsequently assessed. Please see figure 1 for flow sheet of patient selection.

Baseline characteristics of patients under going ablation versus not along with hospital out comes were derived. Length of stay and mean

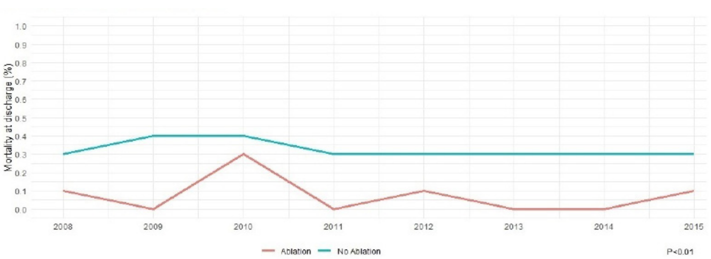

Figure 2: **Trends in mortality in heart failure with reduced ejection fraction and atrial fibrillation patients vs. not over the study years**

Table 1: **Baseline characteristics of the study population stratified on the basis of AF ablation versus not**

Variable no. (%)	No Ablation (n=2562145)	Ablation (n=7773)	All patients with Afib† andHFrEF‡ (n=2569919)	P value
Age (mean [SD]) years	76.2(11.6)	69.6(12)	76.2(11.6)	<0.01
Age <65	415112(16.5%)	2504(33.1%)	417616(16.50%)	<0.01
65-74	521723(20.7%)	2088(27.6%)	523811(20.70%)	<0.01
¬≥75	1584144(62.8%)	2980(39.4%)	1587124(62.80%)	<0.01
Female	1068414(41.70%)	2635(33.90%)	1069086(41.60%)	<0.01
$CHAD_2VASC_2$ score (Median, IQR)	4(2)	3(2)	4(2)	
Race				
Caucasian	1896153(80.2%)	5801(83.7%)	1901954(80.20%)	<0.01
African American	254526(10.8%)	597(8.6%)	255123(10.80%)	
Hispanics	120305(5.1%)	319(4.6%)	120624(5.10%)	
Asian or Pacific Islander	33809(1.4%)	45(0.6%)	33854(1.40%)	
Native American	10747(0.5%)	31(0.4%)	10778(0.50%)	
AHRQ§Medical comorbidity				
Alcohol abuse	72809(2.8%)	211(2.7%)	73020(2.80%)	0.49
Anemia	34472(1.3%)	54(0.7%)	34526(1.30%)	<0.01
Chronic pulmonary disease	858847(33.5%)	2098(27.0%)	860945(33.50%)	<0.01
Coagulopathy	208605(8.1%)	492(6.3%)	209097(8.10%)	<0.01
Diabetes	218960(8.5%)	378(4.9%)	219338(8.50%)	<0.01
Hypertension	1745998(68.1%)	5075(65.3%)	1751073(68.10%)	<0.01
Fluid and electrolyte disorders	895405(34.9%)	1904(24.5%)	897309(34.9%)	<0.01
Liver disease	69092(2.7%)	133(1.7%)	69225(2.70%)	<0.01
Neurological disorders	205974(8.0%)	324(4.2%)	206298(8.0%)	<0.01
Peripheral vascular disorders	354809(13.8%)	843(10.8%)	355652(13.8%)	<0.01
Renal failure	996522(38.9%)	2458(31.6%)	998980(38.9%)	<0.01
History of stroke	226751(8.9%)	498(6.4%)	227249(8.80%)	<0.01
Valvular Disease	273245(10.7%)	131(1.7%)	273376(10.60%)	<0.01
Hospital Location				
Rural	304736(11.9%)	303(3.9%)	305039(11.90%)	<0.01
Urban Non-teaching	943247(36.8%)	1746(22.5%)	944993(36.80%)	
Urban Teaching	1314162(51.3%)	5725(73.6%)	1319887(51.40%)	
Bed size of the hospital				
small	345854(13.5%)	611(7.9%)	346465(13.5%)	<0.01
medium	667961(26.1%)	1506(19.4%)	669467(26.1%)	
large	1548331(60.4%)	5656(72.8%)	1553987(60.5%)	
Region				
Northeast	568435(22.2%)	1722(22.2%)	570157(22.2%)	<0.01
Midwest	666681(26.0%)	1913(24.6%)	668594(26.0%)	
South	930343(36.3%)	3024(38.9%)	933367(36.3%)	
West	396686(15.5%)	1115(14.3%)	397801(15.5%)	
Median household income percentile				
0–25th	722541(28.7%)	2038(26.5%)	724579(28.7%)	<0.01
26–50th	677852(27.0%)	2183(28.4%)	680035(27.0%)	
51–75th	615639(24.5%)	1897(24.7%)	617536(24.5%)	
76–100th	498023(19.8%)	1573(20.5%)	499596(19.8%)	

†Atrial Fibrillation; ‡Heart Failure with reduced Ejection Fraction;§Agency for healthcare research and quality

Table 2: Hospital encounter outcomes and resource utilization of the study cohort

Variables no. (%)	No Ablation (n=2562145)	Ablation (n=7773)	All patients with Afib† and HFrEF‡ (n=2569919)	P value
Died at discharge	124674(4.9%)	91(1.2%)	124765(4.9%)	<0.01
<65	11280(2.7%)	10(0.4%)	11290(2.7%)	<0.01
65-74	21181(4.1%)	31(1.5%)	21212(4.1%)	<0.01
>/=75	90688(5.7%)	49(1.6%)	90737(5.7%)	<0.01
Discharge Disposition of surviving patients				
Routine/self-care	1026629(42.1%)	5420(70.5%)	1032049(42.2%)	<0.01
Short-term hospital	69374(2.8%)	54(0.7%)	69428(2.8%)	
Another type of facility	735372(30.2%)	980(12.8%)	736352(30.1%)	
Home Health Care	589475(24.2%)	1219(15.9%)	590694(24.2%)	
Resource utilization, Mean (SD)				
Length of stay, mean (SD), days	6.1(5.7)	6.2(6.4)	6.1(5.8)	<0.01
Cost of hospitalization-mean (SD), $	46370(69554)	92327 (90984)	46516(69680)	<0.01

†Atrial Fibrillation; ‡Heart Failure with reduced Ejection Fraction

cost of stay (inflation adjusted) were subsequently calculated.

For missing values imputation, multiple iterations of Markov Chain Monte Carlo (MCMC) method were used. To account for potential confounding factors and selection bias, a propensity score-matching model was developed using logistic regression to derive two matched groups for comparative outcomes analysis. Given larger non-ablation group and to minimize case loss, a nearest neighbor 1:2 variable ratio, parallel, balanced propensity-matching model was made using a caliper width of 0.2. Descriptive statistics were presented as frequencies with percentages for categorical variables and as means with standard deviations for continuous variables. Baseline characteristics were compared using a Pearson $x2$ test and Fisher's exact test for categorical variables and independent samples t-test for continuous variables.

Logistic regression was performed to estimate odds ratios (ORs) with 95% confidence intervals (CIs) to determine predictors formortality in our cohort. Initially, binomial logistic regression model was used to identify variables from demographic data (table 1) that were significantly associated with patient mortality (P value < 0.10). These variables were then subsequently utilized in a multiple logistic regression model to identify predictors of mortality. A type I error rate of <0.05 was considered statistically significant. All statistical analyses were performed using statistical package for social science (SPSS) version 26 (IBM Corp) and R 3.5 for propensity matching. All analyses were done on a weighted sample.

Results

A total of 2,569,919 patients with AF and HFrEF were identified from NIS dataset. Out of these, about 7,773 patients underwent AF ablation. Baseline characteristics of the study population are shown in table 1. Patients undergoing ablation tend to be younger when compared to patients not undergoing ablation (69.6 vs. 76.2 years, p < 0.01). 41.6% of the study cohort constituted female patients and ablation was performed in 34% of them. Median $CHAD_2VASC_2$ score was 4(2) for the non-ablation group and 3(2) for the ablation group.

Table 2 illustrates outcomes and resource utilization of our study cohort based on raw unmatched data. A total of 124,765 (4.9%) patients in our study died at discharge. Mortality was significantly lower in the ablation group compared to no ablation group in both unmatched (1.2% vs. 4.9%, p < 0.01) and propensity matched groups (1.2% vs. 3.6%, p < 0.01). Please see table 3 for detailed outcomes after propensity matching. Mortality trend remained low and stable over study years in both ablation and no ablation group (figure 2). There had been a steady increased trend in mean cost for hospital stay over study years in both groups (figure 3).

Overall, 10.2% patients had at least one complication associated with CA (table 4). Complications associated with ablation included stroke (1.8%), myocardial infarction (3.6%), need for percutaneous coronary intervention (0.7%), cardiogenic shock (2.3%),cardiac tamponade (0.7%), vascular complications (0.7%),septic shock (0.7). The incidence of per icardiocentesis was 0.7% in our ablation cohort.

Mortality predictors for AF patients with HFrEF are shown in figure 4. Advanced age (OR 1.027, 95% CI 1.026-1.029), chronic pulmonary disease (OR1.108, 95% CI 1.077-1.139), coagulopathy (OR1.797, 95% CI1.729-1.867), fluid and electrolyte disorders (OR2.242, 95% CI2.182-2.303),peripheral vascular disease (OR 1.128, 95% CI 1.088-1.17), valvular heart disease (OR 1.157, 95% CI 1.111-1.204) and renal failure (OR1.302, 95% CI1.267-1.338) were associated with increased mortality while ablation was independently associated with lower mortality in our cohort (OR0.301, 95% CI 0.184-0.494).

Discussion

The main findings of current study include: (1) AF patients with HFrEF tended to have low mortality if they undergo ablation in both unmatched (1.2% vs. 4.9%, p < 0.01) and propensity matched cohorts (1.2% vs. 3.6%, p < 0.01). (2) CA was an independent predictor of reduced mortality in adjusted mortality analysis. (3) Approximately 10.2% patients had at least one procedure related complication with cardiac and neurologic complications being the most frequent in our cohort.

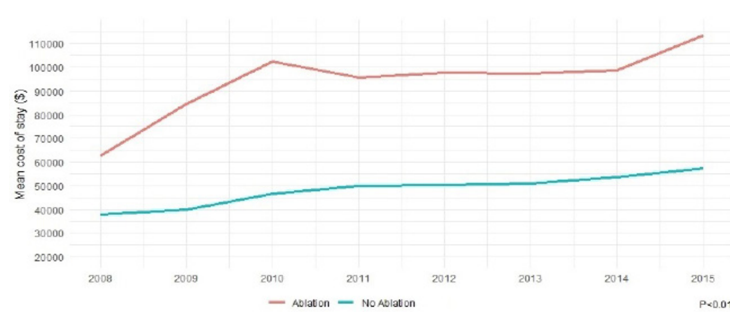

Figure 3: Trends in mean cost of stay in heart failure with reduced ejection fraction and atrial fibrillation patients undergoing ablation vs. not over the study years

Table 3: Outcomes and resource utilization of the study cohort after 1:2 propensity matching

Variables	No Ablation (n=15610)	Ablation (n=7773)	All patients with Afib† andHFrEF‡ (n=2569919)	P value
Died at discharge	565(3.6%)	91(1.2%)	656(2.8%)	<0.01
<65	139(2.5%)	10(0.4%)	149(1.9%)	<0.01
65-74	84(2.4%)	31(1.5%)	115(2.0%)	<0.01
≥75	338(5.4%)	49(1.6%)	387(4.2%)	<0.01
Discharge Disposition of surviving patients				
Routine/self-care	8374(55.7%)	5420(70.5%)	13794(60.7%)	<0.01
Short-term hospital	484(3.2%)	54(0.7%)	538(2.4%)	
Another type of facility	3127(20.8%)	980(12.8%)	4107(18.1%)	
Home Health Care	2998(19.9%)	1219(15.9%)	4217(18.6%)	
Resource utilization, Mean (SD)				
Length of stay, mean (SD), days	5.9(6.6)	6.4(6.9)	6.0(6.7)	<0.01
Cost of hospitalization-mean (SD), $	47,900 (100,799)	93,535(92,919)	63,071(100,572)	0.04

†Atrial Fibrillation; ‡Heart Failure with reduced Ejection Fraction

AF and CHF frequently co-exist and the prevalence of CHF is reported to be 42% in AF patients [14]. AF is associated with frequent hospitalizations and mortality in CHF patients [4,5,6]. Several trails have reported improvement in hard clinical end points of mortality and hospitalizations in AF patients with concomitant HfrEF if CA was employed as part of therapeutic modality [7,8]. In the AATAC study [7], 203 patients with persistent AF and HFrEF were randomized to get either amiodarone or CA. At the end of follow-up, CA was found to be superior to amiodarone in maintain sinus rhythm and improving left ventricular ejection fraction (LVEF). The study also showed 45% relative risk reduction for unplanned hospitalizations and 56% relative risk reduction for mortality in CA patients when compared to amiodarone group. More recently, CASTLE AF [8] enrolled patients with paroxysmal and persistent AF and concomitant HFrEF to either CA or medical therapy with rate or rhythm control. The primary end-point taken in this trial was a composite of all-cause mortality or CHF hospitalizations. At the end of 37 months follow up, primary end point occurred in few patients who underwent CA compared to medical therapy (HR 0.62, 95% CI 0.43-0.87). In our real world analysis of AF patients with HFrEF, we have demonstrated significant improvement in mortality in patients in whom CA was employed as a therapeutic strategy for management of AF. The significant reduction in mortality was uniform in both matched and unmatched cohort. Additionally, in our adjusted mortality analysis, CA was found to independently predict improved mortality in our cohort (OR 0.301, 95% CI 0.184-0.494). Of note, due to limitation of NIS dataset, CA assessment was only done while patients are admitted to inpatient settings. These patients are speculated to be sicker when compared to their counterparts who get elective CA procedure as an outpatient and were the ones primarily enrolled in aforementioned trials. It is pertinent to point here that even in these sick patients, CA was associated with improved survival at discharge suggesting that due consideration should be given to this therapeutic modality for management of such patients.

In our study, about 10.2% patients sustained procedure related complications after CA ablation. In a study by Tripathi et al [12] on recent contemporary trends of CA in AF patients, the overall complication rate was reported at 5.46%. It is pertinent to point out that Tripathi et al. utilized all AF patients for their analysis and did not discriminate based on HFrEF status. Patients admitted with AF and concomitant HFrEF are particularly on the sickest end of spectrum in their disease process. The high complication rate of 10.2% in our study cohort probably reflected variable degree of institution experience in performing CA in these sickest patients. Our study also showed increased rate of myocardial infarction (3.6%) and cardiogenic shock (2.3%) in study population. Some degree of tropon in elevation is frequently encountered post ablation due to localized myocardial necrosis consequent to creation of lesion sets [15], however, about 0.7% patients in our cohort did undergo coronary stenting indicative of type I myocardial infarction. Strong index of suspicion is therefore warranted for timely detection of these key cardiovascular complications as that may result in improved outcomes. In our cohort, about 0.7% patients were found to be septic during the particular hospitalization in which CA was performed. Sepsis typically is a late complication of CA and usually occurs within 30-days of procedure as demonstrated by recent study from Cheng et al. [16] and that may explain relatively low rate of this complication during our patients index hospitalization. The rate of vascular complications was 0.7% and that was similar to reports from earlier studies [12]. Stroke happened in approximately 1.8% of our patients when compared to 1% of patients in Tripathi et al. study [12]. AF perpetuates thrombus formation due to stasis of blood and it is speculated that HFrEF may accentuate this response by promoting further stagnation of blood. It is therefore advised that close attention should be paid to anti-coagulation regimen and activating clotting times during the CA procedure to minimize the risk of strokes in AF patients with concomitant HFrEF.

Limitations

Our study has following key limitations: (1) NIS is an

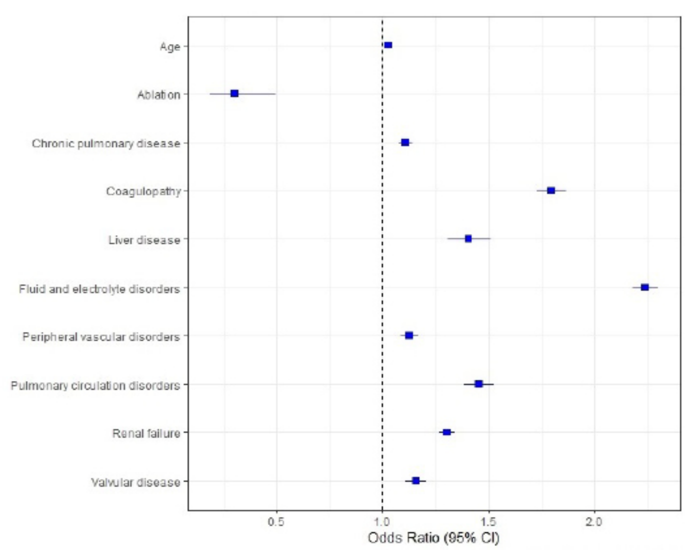

Figure 4: Predictors of mortality in patients with heart failure and reduced ejection fraction and atrial fibrillation

Table 4: Complications in AF ablation patients stratified on the basis of gender

Variableno. (%)	All complications (n=7773)	Men (n=5135)	Women (n=2637)	P value
At least one complication	788(10.2%)	555(10.8%)	233(8.8%)	<0.01
Iatrogenic cardiac complications	121(1.6%)	90(1.80%)	31(1.20%)	0.05
Stroke	138(1.8%)	63(1.20%)	75(2.80%)	<0.01
Vascular complications	55(0.7%)	30(0.6%)	25(0.9%)	0.07
Pneumothorax	21(0.3%)	11(0.2%)	10(0.4%)	0.18
Post-operative respiratory failure	30(0.4%)	20(0.4%)	10(0.4%)	0.94
Need for pericardiocentesis	57(0.7%)	28(0.5%)	29(1.1%)	0.02
Cardiac tamponade	57(0.7%)	28(0.5%)	29(1.1%)	0.07
Cardiogenic shock	181(2.30%)	151(2.90%	30(1.10%	<0.01
Septic shock	54(0.7%)	44(0.9%)	10(0.4%)	0.02
Myocardial infarction	277(3.6%)	204(4.0%)	73(2.8%)	<0.01
Percutaneous coronary intervention	53(0.7%)	44(0.9%)	9(0.3%)	<0.01
Pulmonary embolism	44(0.6%)	29(0.6%)	15(0.6%)	0.98

administrative claim-based database that uses ICD-9-CM codes for diagnosis that may be subject to error. However, the hard clinical end point of mortality and procedure code for ablation are less prone to error. Additionally, HCUP quality control measures are routinely performed on NIS dataset to ensure continued reliability and validity [13]. (2) NIS collects data on inpatient discharges and do not reflect on outpatient related encounters. Currently, most AF ablations are done as an elective outpatient procedure and these patients are relatively less sick and expected to have lower mortality and complication rate when compared to our sample of admitted AF patients. Nonetheless, our study reflects real word data on outcomes in these sickest hospitalized AF patients after CA and largely representative of United States population sample. (3) Several patient related factors such as type and duration of AF, cardiac parameters such as chamber dimensions and ejection fraction and procedure related factors such as type of lesions performed (pulmonary vein isolation alone or in combination with left atrial roof and floor lines etc.) and type of energy used to create lesion sets could not be ascertained from present data set. (4) NIS does not collect longitudinal data on patients so long term follow up could not be assessed. To the same end, certain specific CA complications such as development of an atrio-esophageal fistula occurs weeks to months after the procedure and unfortunately the incidence of this complication could not be studied from NIS.

Conclusion

In this large nationally representative sample of United States population, we demonstrated that CA is associated with reduced mortality in AF patients with HFrEF in both matched and unmatched cohorts. The complication rate was 10.2% and primarily were cardiac and neurological in origin.

Link for Supplementary Content

References

1. Braunwald E. Shattuck lecture: cardiovascular medicine at the turn of the millennium. Triumphs, concerns, and opportunities. N Engl J Med. 1997;337:1360–1369.
2. Li D, Fareh S, Leung TK, et al. Promotion of atrial fibrillation by heart failure in dogs: atrial remodeling of a different sort. Circulation. 1999;100:87–95.
3. Shinbane JS, Wood MA, Jensen DN, et al. Tachycardia-induced cardiomyopathy: a review of animal models and clinical studies. J Am Coll Cardiol. 1997;29:709–715.
4. Middlekauff HR, Stevenson WG, Stevenson LW. Prognostic significance of atrial fibrillation in advanced heart failure: a study of 390 patients. Circulation. 1991;84:40–48.
5. Dries DL, Exner DV, Gersh BJ, et al. Atrial fibrillation is associated with an increased risk for mortality and heart failure progression in patients with asymptomatic and symptomatic left ventricular systolic dysfunction: a retrospective analysis of the SOLVD trials. Studies of Left Ventricular Dysfunction. J Am Coll Cardiol. 1998;32:695–703.
6. Aronow WS, Ahn C, Kronzon I. Prognosis of congestive heart failure after prior myocardial infarction in older persons with atrial fibrillation versus sinus rhythm. Am J Cardiol. 2001;87:224–225.
7. Di Biase L, Mohanty P, Mohanty S, Santangeli P, Trivedi C, Lakkireddy D, Reddy M, Jais P, Themistoclakis S, Dello Russo A, Casella M, Pelargonio G, Narducci ML, Schweikert R, Neuzil P, Sanchez J, Horton R, Beheiry S, Hongo R, Hao S, Rossillo A, Forleo G, Tondo C, Burkhardt JD, Haissaguerre M, Natale A.Ablation Versus Amiodarone for Treatment of Persistent Atrial Fibrillation in Patients With Congestive Heart Failure and an Implanted Device: Results From the AATAC Multicenter Randomized Trial. Circulation. 2016;133:1637-44.
8. Marrouche NF, Brachmann J, Andresen D, Siebels J, Boersma L, Jordaens L, Merkely B, Pokushalov E, Sanders P, Proff J, Schunkert H, Christ H, Vogt J, Bänsch D. Catheter Ablation for Atrial Fibrillation with Heart Failure. N Engl J Med. 2018;378:417-427.
9. Deshmukh A, Patel NJ, Pant S, Shah N, Chothani A, Mehta K, Grover P, Singh V, Vallurupalli S, Savani GT, Badheka A, Tuliani T, Dabhadkar K, Dibu G, Reddy YM, Sewani A, Kowalski M, Mitrani R, Paydak H, Viles-Gonzalez JF.In-hospital complications associated with catheter ablation of atrial fibrillation in the United States between 2000 and 2010: analysis of 93 801 procedures. Circulation. 2013;128:2104-12.
10. Shah RU, Freeman JV, Shilane D, Wang PJ, Go AS, Hlatky MA. Proceduralcomplications, rehospitalizations, and repeat procedures after catheter ablation for atrial fibrillation. J AmCollCardiol. 2012;59:143–149.
11. Ellis ER, Culler SD, Simon AW, Reynolds MR. Trends in utilization and complications of catheter ablation for atrial fibrillation in Medicare beneficiaries. Heart Rhythm. 2009;6:1267–1273.
12. Tripathi B, Arora S, Kumar V, Abdelrahman M, Lahewala S, Dave M, Shah M, Tan B, Savani S, Badheka A, Gopalan R, Shantha GPS, Viles-Gonzalez J, Deshmukh A.Temporal trends of in-hospital complications associated with catheter ablation of atrial fibrillation in the United States: An update from Nationwide Inpatient Sample database (2011-2014).J Cardiovasc Electrophysiol. 2018;29:715-724.
13. Agency for Healthcare Research and Quality. Overview of the national (nationwide) inpatient sample (NIS). Rockville: AHRQ; https://www.hcup-us.ahrq.gov/nisoverview.jsp#about. Published 2019. Accessed on November 12, 2019
14. Maisel WH, Stevenson LW. Atrial fibrillation in heart failure: epidemiology, pathophysiology, and rationale for therapy.Am J Cardiol. 2003; 91:2D–8D.
15. Yoshida K, Yui Y, Kimata A, Koda N, Kato J, Baba M, Misaki M, Abe D, Tokunaga C, Akishima S, Sekiguchi Y, Tada H, Aonuma K, Takeyasu N.Troponin elevation after radiofrequency catheter ablation of atrial fibrillation: relevance to AF substrate, procedural outcomes, and reverse structural remodeling. Heart

Rhythm. 2014;11:1336-42.

16. Cheng EP, Liu CF, Yeo I, Markowitz SM, Thomas G, Ip JE, Kim LK, Lerman BB, Cheung JW.Risk of Mortality Following Catheter Ablation of Atrial Fibrillation. J Am Coll Cardiol. 2019;74:2254-2264.