Healthcare Utilization and Quality of Life Improvement after Ablation for Paroxysmal AF in Younger and Older Patients

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Background: *Atrial fibrillation (AF) prevalence increases significantly with age. Little is known about the effect of AF ablation on quality of life and healthcare utilization in the elderly. The objective of this study was to quantify the healthcare utilization and quality of life benefits of catheter ablation for AF, for patients ≥65 years compared to patients <65 years.*

Methods: *Two multicenter U.S. registry studies enrolled patients with paroxysmal AF. Baseline characteristics and acute outcomes were collected for 736 patients receiving catheter ablation with the NAVISTAR® THERMOCOOL® SF Catheter (Biosense Webster, Inc., Diamond Bar, CA, USA). Healthcare utilization and quality of life outcomes were collected through 1 year postablation for 508 patients.*

Results: *The rates of acute pulmonary vein isolation were high and similar between patients ≥65 years and <65 years (97.5% vs 95.8%, P = 0.2130). Length of stay for the index procedure was similar between age groups with 82.2% of the older group and 83.2% of the younger group having one-day hospitalization. Disease-specific quality of life instrument scores improved significantly and similarly for older and younger patients at 1 year postablation, compared to baseline. AF-related hospitalizations and emergency department visits were similar or lower in older patients compared to younger patients, as reported at 1 year postablation.*

Conclusion: *For older patients undergoing catheter ablation for paroxysmal AF, healthcare utilization parameters were lower or not significantly different than for younger patients, and quality of life outcomes were similarly improved. These findings support the use of catheter ablation as a treatment option in older patients with paroxysmal AF. (PACE 2017; 40:391–400)*

atrial fibrillation, catheter ablation, healthcare utilization, quality of life, elderly, Medicare

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Introduction

Atrial fibrillation (AF) is the most common sustained arrhythmia, and studies show that its prevalence and incidence continue to rise.[1] The risk of developing AF increases significantly with age and accelerates in patients over 65 years of age.[1,2] Radiofrequency ablation is currently recommended as a second-line therapy in patients with symptomatic paroxysmal and persistent AF after at least one antiarrhythmic drug (AAD) has failed.[3] Even though the average age of patients undergoing AF ablation procedures has been increasing in recent years, there is a paucity of information regarding AF ablation outcomes in the elderly.[3,4] The few studies that do report on AF ablation in elderly populations have focused primarily on safety and AF recurrence.[5–8]

Patients suffering from AF commonly describe considerable impairment in quality of life (QoL).[9,10] Improvement in QoL following treatment of AF has been shown to be directly correlated with the restoration and maintenance of a normal sinus rhythm (NSR).[9–12] However, it is unclear whether older patients experience an improved QoL after catheter ablation. Therefore, there is a need to better understand the comprehensive effects of catheter ablation in older populations.

This analysis summarizes patient outcomes utilizing data collected in two prospective multicenter observational registry studies (SFAF and IUAF) in the United States. Both studies were designed to measure "real-world" acute procedural outcomes associated with the use of the NAVISTAR® THERMOCOOL® SF Ablation Catheter (Biosense Webster, Inc., Diamond Bar, CA, USA) in a clinical setting in patients with symptomatic paroxysmal AF refractory to at least one antiarrhythmic agent. In addition, the SFAF study evaluated the effect of the ablation procedure on healthcare utilization, QoL, and employment status through 1 year postprocedure. The primary objective of this paper is to report on the clinical effectiveness and healthcare utilization outcomes of the SFAF and IUAF studies and the impact of catheter ablation on health-related QoL measures.

Methods

Study Design

The NAVISTAR® THERMOCOOL® SF Catheter: Observational Study (SFAF) and CARTO®3 System and Real Time Intracardiac Ultrasound (IUAF) registry studies included patients who were 18 years or older with drug-refractory, recurrent, symptomatic, paroxysmal AF and no prior ablation for their AF. The SFAF study included 45 U.S. clinical centers, with outcomes evaluated during RFA, immediately post-RFA, at discharge, at day 7, and at 6 and 12 months. The IUAF study included 26 U.S. sites, with outcomes evaluated during RFA, immediately post-RFA, at discharge, and at day 7. This analysis combines acute endpoints from the SFAF and IUAF studies and includes available information for clinical effectiveness and utilization outcomes at the time that the databases were locked.

Study Population

A total of 736 patients were enrolled in the two studies and had ablations performed with the study catheter: 508 from the SFAF study and 228 from the IUAF study (Table I). Of the total, 381 were <65 years of age (264 SFAF, 117 IUAF) and 355 were 65 years of age or older (244 SFAF, 111 IUAF). The mean age of the older group was 71.1 with standard deviation (SD) of 4.9 years (range 65–85). The mean age of the younger group was 53.6 years with SD of 9.1 (range 23–64). Significant differences in baseline characteristics in the older versus younger patients included the following: fewer males; higher rates of anticoagulation usage, hypertension, transient ischemic attack, and coronary artery disease; and higher $CHADS_2$ risk scores (Table I).

AF Ablation Procedure

The AF ablation procedures included pulmonary vein isolation performed with a 56-hole porous-tip ablation catheter (NAVISTAR® THERMOCOOL® SF Catheter) and three-dimensional (3D) electroanatomical mapping (CARTO® 3 System, Biosense Webster, Inc.). All of the IUAF procedures and some of the SFAF procedures also included use of the SOUNDSTAR® Catheter for 3D intracardiac echocardiography. Ablation methodology was at the discretion of the operators with minimal recommendations, as reported previously for these trials.[6]

Statistical Analysis

Descriptive statistics were used to summarize pooled procedural data from both studies and 1-year endpoints from the SFAF study. Continuous data were expressed as means and SDs. Categorical outcomes were presented as the number and percentages of events.

Study Endpoints and Definitions

The IUAF study followed patients for only 7 days postablation, collecting data on acute procedural success, procedural efficiency, and adverse events. The SFAF study followed patients through 12 months postablation, collecting the same acute endpoints, as well as information on healthcare utilization measures including

Table I.

Baseline Patient Characteristics

	Overall		Patients <65 Years		Patients 65+ Years	
Category	**n**	**Percent**	**n**	**Percent**	**n**	**Percent**
Total N	736	100%	381	100.0%	355	100%
Study						
IUAF	228	31.0%	117	30.7%	111	31.3%
SFAF	508	69.0%	264	69.3%	244	68.7%
Sex‡						
Female	284	38.6%	126	33.1%	158	44.5%
Male	452	61.4%	255	66.9%	197	55.5%
Anticoagulant usage*	615	83.6%	306	80.3%	309	87.0%
Baseline comorbidities						
Hypertension§	503	68.3%	224	58.8%	279	78.6%
Diabetes	131	17.8%	64	16.8%	67	18.9%
Pulmonary disease	42	5.7%	20	5.2%	22	6.2%
Congestive heart failure	62	8.4%	30	7.9%	32	9.0%
NYHA I	18	2.4%	8	2.1%	10	2.8%
NYHA II	42	5.7%	20	5.2%	22	6.2%
NYHA unknown	2	0.3%	2	0.5%	0	0.0%
Stroke - Thromboembolic	13	1.8%	5	1.3%	8	2.3%
Stroke - Not Thromboembolic	9	1.2%	5	1.3%	4	1.1%
Transient ischemic attack*	30	4.1%	9	2.4%	21	5.9%
Coronary artery disease§	159	21.6%	53	13.9%	106	29.9%
Obesity	172	23.4%	101	26.5%	71	20.0%
$CHADS_2$ Risk Score§						
0	205	27.9%	144	37.8%	61	17.2%
1	308	41.8%	158	41.5%	150	42.3%
2	157	21.3%	56	14.7%	101	28.5%
3	51	6.9%	20	5.2%	31	8.7%
4	13	1.8%	3	0.8%	10	2.8%
5	2	0.3%	0	0.0%	2	0.6%
6	0	0.0%	0	0.0%	0	0.0%
Cardiac Measures	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
Left atrial size (mm)	42.4	25.8	43.5	33.7	41.1	11.3
Ejection fraction	57.8%	8.6%	57.5%	8.4%	58.1%	8.8%

IUAF = Registry Identifier; NYHA = New York Heart Association; SFAF = Registry Identifier.
*P-value for difference between younger and older patients is ≤0.05.
†P-value for difference between younger and older patients is ≤0.01.
‡P-value for difference between younger and older patients is ≤0.001.
§P-value for difference between younger and older patients is ≤0.0001.

inpatient length of stay (LOS), repeat ablations procedures, repeat hospitalizations, emergency department visits, and outpatient office visits; and QoL measures including Atrial Fibrillation Effect on Quality of Life (AFEQT) score and lost work days. Acute procedural success was defined as isolation of all targeted pulmonary veins. LOS was calculated as the total length of the index ablation visit, and also as the subset of days from the ablation procedure to hospital discharge. Patients with total LOS > 1 week were investigated to determine whether the increased LOS was due to an extended preablation visit, exacerbation of a comorbid event, or a procedure-related adverse event. Outcomes of interest were also summarized by age cohort to compare younger patients (<65 years of age) versus older patients (age 65 years and over).

All outcomes were summarized for the total population of enrolled patients who underwent catheter ablation with the study catheter and who had complete data. QoL was measured with a disease-specific instrument, the AFEQT Questionnaire.[13] This instrument produces an overall QoL score, along with three scores for subscales relating to symptoms, daily activities, and treatment concern. In addition, it includes two questions related to patient satisfaction that are scored independently and not included in the overall score. In brief, higher AFEQT scores correlate with self-reported improvement in symptoms. Employment status at baseline, along with any changes in status, was reported at 6 and 12 months postablation. Lost work days due to any cause and specifically due to AF were also recorded at the 6- and 12-month postablation visits.

All statistical comparisons of continuous data utilized *t*-tests and all statistical comparisons of count data utilized Pearson's χ^2 tests. All analyses were performed using SAS version 9.2 (SAS Institute Inc., Cary, NC, USA).

Results

Procedural Success

Acute procedural success (i.e., pulmonary vein isolation in all targeted veins) was achieved in 711 of 736 patients (96.6%). The acute success rate was not significantly different in older versus younger cohorts (97.5% vs 95.8%, P = 0.2130) or in females versus males (97.9% vs 95.8%, P = 0.1274) (Table II).

Patient Follow-Up

All 736 patients who had ablations performed with the study catheter also had procedural detail and acute safety information available. Of the 508 patients in the longer SFAF study, six died during the follow-up period and 23 were lost to follow-up, leaving 479 patients with 12-month visits.

LOS

The majority of patients had a total LOS of 1 day, with no significant difference between younger versus older cohorts (78% overall, 79% of patients <65, 77% of patients 65+). The overall distribution of total LOS was not different between age cohorts (P = 0.3327), nor was the distribution of days from procedure to discharge (P = 0.7503). A total of 11 patients had postablation LOS of >5 days, of whom three were <65 years, six were 65–74 years, and two were 75+ years. Of these patients with extended hospital stays, four had serious adverse events (SAEs) that were adjudicated to be related to the procedure or the device, including two cardiac tamponades in patients <65 years and two vascular access complications in patients 65+ years. An additional six of the patients with extended LOS, all of whom were 65+ years, had

Table II.

Ablation Outcomes

	Total Population			Patients <65 Years			Patients 65+ Years		
	N	Count	Percent	N	Count	Percent	N	Count	Percent
Length of Stay after Ablation									
0 days	735	17	2.3%	381	9	2.4%	354	8	2.3%
1 day	735	608	82.7%	381	317	83.2%	354	291	82.2%
2 days	735	58	7.9%	381	31	8.1%	354	27	7.6%
3 days	735	22	3.0%	381	12	3.1%	354	10	2.8%
4 days	735	9	1.2%	381	5	1.3%	354	4	1.1%
5 days	735	10	1.4%	381	4	1.0%	354	6	1.7%
>5 days	735	11	1.5%	381	3	0.8%	354	8	2.3%
Acute success (isolation of PVs)	736	711	96.6%	381	365	95.8%	355	346	97.5%
Repeat ablations	508	74	14.6%	264	39	14.8%	244	35	14.3%
	N	Mean (SD)	Range	N	Mean (SD)	Range	N	Mean (SD)	Range
Days to 1st Repeat Ablation	74	172 (91)	(16, 429)	39	175 (85)	(16, 349)	35	168 (99)	(20, 429)

PV = pulmonary vein; SD = standard deviation.

Table III.

Healthcare Utilization Reported at 12 Months Postablation

	Total Population (N = 479)			Patients <65 Years (N = 235)			Patients 65+ Years (N = 254)		
Utilization Type	**Patients with Visit**	**Percent of Patients**	**Median # per Patient**	**Patients with Visit**	**Percent of Patients**	**Median # per Patient**	**Patients with Visit**	**Percent of Patients**	**Median # per Patient**
All-cause visit(s)									
Inpatient hospitalization†	139	28.4	1	80	34.0	1	59	23.2	1
Outpatient emergency visit	120	24.5	1	64	27.2	1	56	22.0	1
Outpatient office visit§	380	77.7	13	201	85.5	13	179	70.5	10
AF-related visit(s)									
Inpatient hospitalization	73	14.9	1	40	17.0	2	33	13.0	1
Outpatient emergency visit	56	11.5	1	23	9.8	1	33	13.0	1
Outpatient office visit*	323	66.1	10	167	71.1	10	156	61.4	8

*P-value for difference between younger and older patients is ≤0.05.
†P-value for difference between younger and older patients is ≤0.01.
‡P-value for difference between younger and older patients is ≤0.001.
§P-value for difference between younger and older patients is ≤0.0001.

unrelated SAEs. One patient <65 years had a 9-day LOS with no reported adverse events. In addition, three patients with only 2–3 days from procedure to discharge were admitted 8–13 days prior to the procedure, resulting in extended total stays (Table II).

Repeat Ablations

A total of 74 patients (14.6%) of 508 in the SFAF study had repeat ablations occurring prior to their 12-month follow-up visit. The repeat ablation rate was similar in the younger and older cohorts (14.8% vs 14.3%). For those patients with repeat ablations prior to their 12-month visit, the mean time to reablation was 172 days (SD 91 days), and the difference in distribution of times between the older and younger cohorts was not statistically significant (age <65: mean 175 days, SD 85 days; age 65+: mean 168 days, SD 99 days) (Table II).

Repeat Hospitalizations, ED Visits, and Outpatient Visits

All-cause hospitalization rates were significantly lower in the older cohort than in the younger cohort (34.0% vs 23.2%, P = 0.0081). AF-related hospitalization rates were lower in the older cohort than in the younger group but the difference was not statistically significant (13.0% vs 17.0%, P = 0.2620). The percentage of patients with all-cause outpatient emergency visits was higher in the younger cohort, whereas the percentage with AF-related visits was higher in the older cohort, but neither difference was statistically significant (P = 0.1830 and P = 0.2080). Significantly more younger patients than older patients reported outpatient office visits, both for all-cause and specifically for AF (P < 0.0001 and P = 0.0182) (Table III).

QoL

Of the 508 patients in the SFAF study, 506 had completed AFEQT surveys at screening and 464 had completed surveys at their 1-year follow-up visit, resulting in 462 patients for whom a change in the scale score could be calculated. These patients showed substantial improvement in QoL at 1 year after ablation in all subscale categories (Fig. 1A). On scales ranging from 0 (lowest QoL score on every question) to 100 (highest QoL score on every question), patients scored an average of 33 points higher at 1 year postablation than they did preablation. Gains of 35–38 points, on average, were realized in each subscore for categories related to symptoms, daily activities,

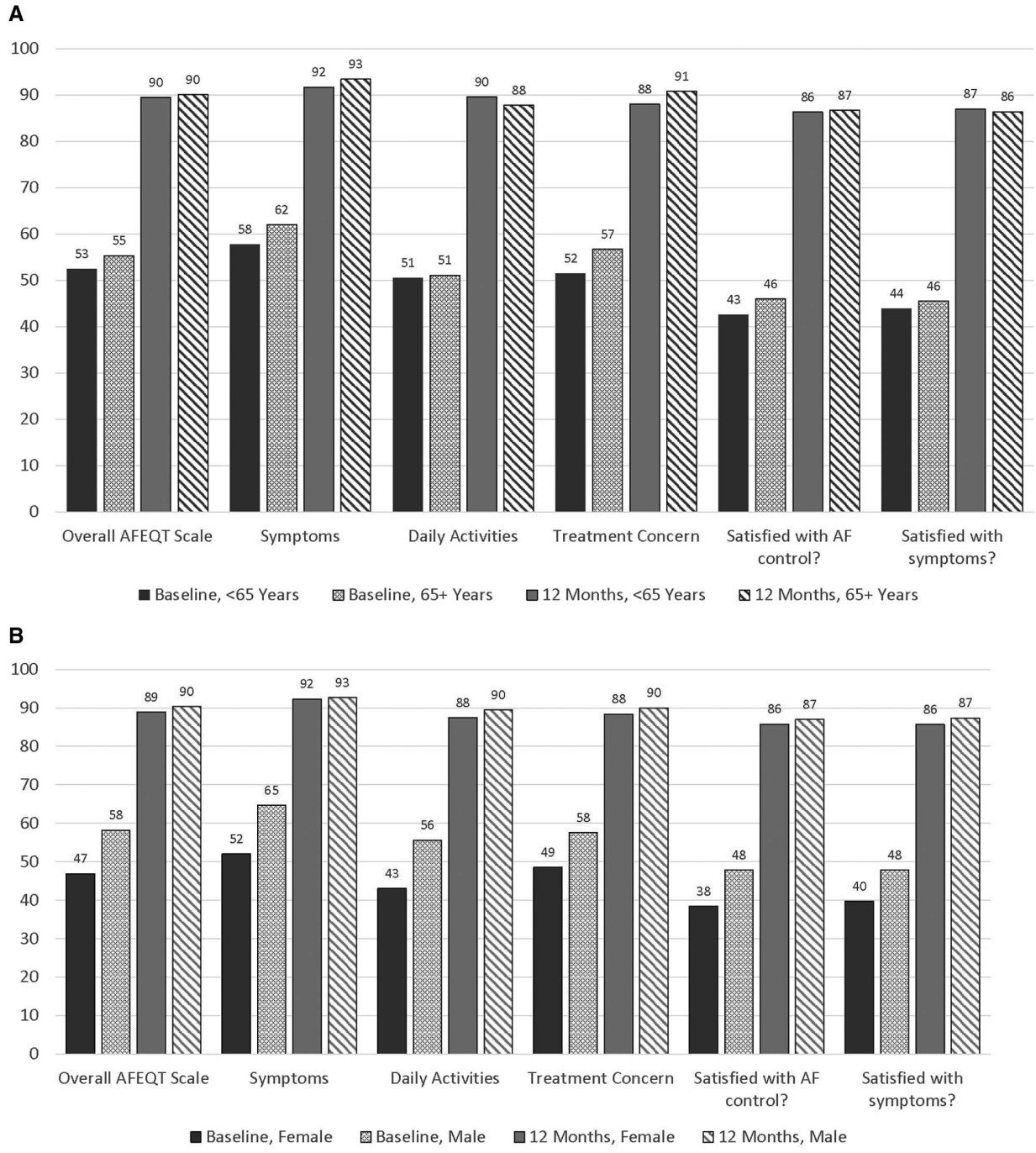

Figure 1. *(A) Mean AFEQT scores at baseline versus 12-month visit by age group. (B) Mean AFEQT scores at baseline versus 12-month visit by sex. AFEQT = atrial fibrillation effect on quality of life.*

and treatment concerns. In addition, summary questions regarding patient satisfaction with both AF control and symptoms doubled from baseline levels.

AFEQT score increases were similar in older and younger patients, with increases in the younger patients of just a few points more than in older patients across all subscores and patient satisfaction questions (P-values for age cohort ranging from 0.3016 for the overall score to 0.4948 for patient satisfaction with symptoms) (Fig. 1A). All AFEQT scores increased significantly from

baseline to the 12-month follow-up visit and were greater for females than for males as a result of female patients having lower baseline scores, but similar 12-month scores (P-values for sex ranging from <0.0001 for the overall score to 0.0501 for patient satisfaction with symptoms) (Fig. 1B).

Though this study was designed to compare patients age 65 and over versus patients <65 years, gains in overall QoL scores from the AFEQT were similar even in the more senior patients within the older cohort, though sample sizes dropped off substantially with advancing age. Mean gains in the overall AFEQT scale from baseline to 12 months were 37.1 for age < 65 years (N = 236) and 34.8 for patients age 65+ years (N = 226), with a gain of 30.1 in the subset of age 75+ years (N = 53) and a gain of 34.2 in the subset of age 80+ years (N = 14).

In order to further understand how the observed increases in QoL scores could potentially be impacted by patient characteristics that differ with age, we ran a regression model to adjust for the differences seen between the older and younger patients at baseline. The change in total AFEQT score from baseline was significantly impacted only by a patient's baseline AFEQT score (P < 0.0001). Sex, age group, $CHADS_2$ score, anticoagulation usage, hypertension, transient ischemic attack, and coronary artery disease did not affect the patient's improvement in QoL (P-value range: 0.2535–0.9483).

Discussion

The prevalence of AF in the United States is estimated at 3 million, affecting one in 25 adults ≥60 years of age and almost one in 10 ≥80 years of age.[14,15] These rates are expected to increase 2.5-fold in the next 50 years, with a disproportionate increase in older adults.[14] In addition, given the older age of the patients, patients with AF have a high burden of comorbidities, with many of these being risk factors for stroke in AF, including hypertension, diabetes, and heart failure.[16] AF, as well as these comorbidities, have been shown to directly impact health-related QoL.[16,17] Therefore, research investigating the utilization and benefit of AF ablation in elderly patients is critical.

Healthcare Utilization

The benefits of catheter ablation in the elderly population are increasingly being reported.[4–8,14,16] In a study of patients undergoing ablation at Johns Hopkins Hospital, Hoyt et al. reported some important trends: a steady increase in the number of ablation procedures (25 in 2001 vs 142 in 2005) and repeat procedures (four in 2001 vs. 56 in 2009), an increase in the mean age of patients undergoing ablation (52 years in 2001 vs 60 years in 2009), a shorter duration of AF prior to referral for ablation (7.8 years in 2001 vs 4.2 years in 2009), and a decrease in the number of AADs used prior to first ablation (2.3 vs 1.2).[4] In a population of 261 AF patients ≥75 years old undergoing catheter ablation, 83% remained in NSR with lower mortality and stroke risks at mean follow-up time of 3 ± 2.5 years.[8] In a study by Corrado et al., 73% of septuagenarians maintained sinus rhythm with a single ablation procedure over a mean follow-up period of 20 ± 14 months.[5] Wokhlu et al. reported freedom from recurrence in 69% of patients at 2 years follow-up.[18]

In this study, all of the longer-term healthcare utilization and QoL endpoints showed similar results for younger and older patients. These findings enhance previous studies that reported healthcare utilization in AF ablation patients. Bulkova et al. reported a decrease in the hospital admission rate from 48% before index ablation to 25%, 17%, and 8% in the subsequent 3 years in patients with paroxysmal AF.[19] Both all-cause and AF-related readmission rates were lower in the SFAF study than in a published study reporting on utilization after ablations that occurred between 2005 and 2008 using the California State Inpatient Database.[20]

QoL

An important goal of AF catheter ablation procedures is to improve patients' QoL. In the AF population, QoL improves with treatment and improvement is associated with maintenance of NSR.[5,8,12,21] For older patients, QoL has been shown to significantly decrease with increasing age[22] and AF ablation has been shown to significantly improve the QoL in AF patients.[12,22–27] Quantification of symptom improvement through assessment of health-related QoL is a critical component in evaluating patient outcomes and clinical effectiveness of AF ablation.[26,28] The AFEQT is a disease-specific questionnaire that has been shown to be valid, reliable, and sensitive to clinical change in patients with AF.[29]

In this study, the AFEQT showed substantial improvement in QoL at 1 year after ablation compared to baseline in all subscale categories. QoL was improved significantly in the older cohort of patients ≥65 years and this improvement appeared to remain stable for subsets of patients age 75+ and 80+ years. These findings enhance the findings previously reported in several studies, which largely reported QoL improvements undifferentiated by age.[18,23–25,27]

Study Limitations

The primary limitation of this study is that the data are derived from single-arm prospective

observational cohorts rather than from randomized controlled trials. For this reason, the studies may represent a group of patients undergoing ablation procedure that have a more favorable risk profile than the overall AF population. In particular, the elderly patients may be healthier than average AF patients their age, potentially representing the most robust of this elderly population. Nevertheless, several studies have shown that of the elderly who do present for ablation, outcomes are favorable when compared with the younger population.[5,6,8] In addition, "real-world" studies such as this provide valuable complementary information and insights to data derived from randomized controlled trials due to fewer inclusion and exclusion criteria and a broader range of participating clinical sites.

Another limitation of the SFAF study is the potential for bias in the 1-year endpoints due to an outcome differential between patients who were lost to follow-up or had missing endpoints and those who had nonmissing endpoints. This is related to the limitation discussed above in that a single-arm observational study does not allow for a comparison of the rates of missing values between cohorts. It is important to note that the findings of this study apply only to patients with paroxysmal AF, and should not be extrapolated to patients with persistent/chronic AF. In addition, the collection of postablation rhythm status and AAD therapy were beyond the scope of the data collection for these clinical trials, thus precluding analysis of AF recurrence.

Conclusions

Catheter ablation with the NAVISTAR® THERMOCOOL® SF Ablation Catheter is associated with improved outcomes for both younger and older patients with nonvalvular paroxysmal AF. AF ablation in older patients was not associated with increased LOS, repeat ablations, AF-related repeat hospitalizations, or emergency department visits during the 12 months postablation when compared to a younger group. QoL endpoints were also similar for older versus younger patients, including AFEQT score improvement and number of lost work days. AF ablation in patients ≥65 years is an effective strategy for longer-term improvement of both healthcare utilization and QoL.

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Appendix

SFAF Study (45 U.S. centers)

1. Central Baptist Hospital (Lexington, KY) – Dr. Gery Tomassoni
2. Florida Hospital (Orlando, FL) – Dr. Scott Pollak
3. Scottsdale Healthcare Research Institute, Scottsdale Healthcare/Shea Medical Center (Scottsdale, AZ) – Dr. Andy Tran
4. St. Vincent's Ambulatory Care, Inc. (Jacksonville, FL) – Dr. Saumil Oza
5. Alaska Heart Institute, LLC. (Anchorage, AK) – Dr. Steven Compton
6. St. Joseph's Hospital of Atlanta/Emory University (Atlanta, GA) – Dr. Anshul Patel
7. JFK Medical Center (Atlantis, FL) – Dr. Robert Fishel
8. Cardiovascular Research Foundation of Louisiana (Baton Rouge, LA) – Dr. Kenneth Civello
9. Bethesda North Hospital (Cincinnati, OH)– Dr. Gaurang Gandhi
10. University of Cincinnati (Cincinnati, OH)– Dr. Alexandru Costea
11. Riverside Methodist Hospital (Columbus, OH) – Dr. Sreedhar Billakanty
12. Florida Hospital Memorial Medical Center (Daytona Beach, FL) – Dr. James Wang
13. Central Bucks Specialists, LTD. (Doylestown, PA) – Dr. John Harding
14. Alexian Brothers Medical Center (Elk Grove Village, IL) – Dr. Mohammad Khan
15. Baylor All Saints Medical Center (Fort Worth, TX) – Dr. Vijay Jayachandran
16. Lutheran Medical Group, LLC., Northern Indiana Research Alliance (Fort Wayne, IN) – Dr. Sree Karanam
17. Plaza Medical Center (Grapevine, TX) – Dr. Craig Delaughter
18. Bellin Memorial Hospital, Inc. (Green Bay, WI) – Dr. Mohammad Jazayeri
19. Texas Heart Institute at St. Luke's Episcopal Hospital (Houston, TX) – Dr. Abdi Rasekh
20. Heart Center Research, LLC., Huntsville Hospital (Huntsville, AL) – Dr. Scott Allison
21. University of Iowa Hospital and Clinics (Iowa City, IA) – Dr. Alexander Mazur
22. University of Kansas Hospitals (Kansas City, KS) – Dr. Dhanunjaya Lakkireddy
23. St. Luke's Mid America Heart Institute (Kansas City, MO) – Dr. Alan Wimmer
24. Scripps Clinical Research, Scripps Memorial Hospital (La Jolla, CA) – Dr. Ali Hamzei
25. Largo Medical Center (Largo, FL) – Dr. Shalin Shah
26. Brian LGH Heart Institute (Lincoln, NE) – Dr. Michael Kutayli
27. Baptist Hospital East (Louisville, KY) – Dr. John Mandrola
28. North Shore University Hospital (Mahnasset, NY) – Dr. Stuart Beldner
29. University of Chicago Medical Center (Chicago, IL) – Dr. Joshua Moss
30. Centennial Medical Center (Nashville, TN) – Dr. Greg Bashian
31. Vanderbilt Heart and Vascular Institute (Nashville, TN) – Dr. Patrick Whalen
32. New York Presbyterian Hospital, Columbia University Medical Center (New York, NY) – Dr. Angelo Biviano

33. Creighton University Medical Center (Omaha, NE) – Dr. Hussam Abuissa
34. Albert Einstein Medical Center (Philadelphia, PA) – Dr. Sumeet Mainigi
35. San Diego Cardiac Center, Sharp Memorial Hospital (San Diego, CA) – Dr. Charles Athill
36. UCSF Medical Center (San Francisco, CA) Dr. Edward Gerstenfeld
37. St. Joseph's Hospital, Savannah (Savannah, GA) – Dr. Michael Chisner
38. Arizona Heart Hospital (Phoenix, AZ) – Dr. Vijendra Swarup
39. St. John's Hospital (Springfield, IL) – Dr. Ziad Issa
40. Cardiac Study Center Inc., P.S. (Tacoma, WA) – Dr. Tariq Salam
41. Washington Adventist Hospital (Takoma Park, MD) – Dr. Sung Lee
42. Gensesis Healthcare Systems (Zanesville, OH) – Dr. Magdy Migeed
43. Morristown Medical Center (Morristown, NJ) – Dr. Jonathan Sussman
44. Tampa General Hospital (Tampa, FL) – Dr. Bengt Herweg
45. United Heart & Vascular Clinic, United Hospital (St. Paul, MN) – Dr. Pierce Vatterott

IUAF Study (26 U.S. centers)

1. Osceola Regional Medical Center (Kissimmee, FL) – Dr. Usman Siddiqui
2. Hospital of the University of Pennsylvania (Philadelphia, PA) – Dr. Mathew Hutchinson
3. Scottsdale Healthcare Research Institute (Scottsdale, AZ) – Dr. Andy Tran
4. St. Vincent's Ambulatory Care, Inc. (Jacksonville, FL) – Dr. Saumil Oza
5. JFK Medical Center (Atlantis, FL) – Dr. Robert Fishel
6. Arizona Heart Hospital (Phoenix, AZ) – Dr. Vijendra Swarup
7. Washington Adventist Hospital (Takoma Park, MD) – Dr. Mohit Rastogi
8. Santa Barbara Cottage Hospital (Santa Barbara, CA) – Dr. Brett Gidney
9. University of Nebraska Medical Center (Omaha, NE) – Dr. John Scherschel
10. Pepin Heart Hospital (Tampa, FL) – Dr. Dilip Mathew
11. University of Colorado, Denver (Aurora, CO) – Dr. William Sauer
12. Medical College of Wisconsin (Milwaukee, WI) – Dr. Marcie Berger
13. Kettering Medical Center (Kettering, OH) – Dr. Shahid Baig
14. Tallahassee Research Institute, Inc. (Tallahassee, FL) – Dr. Farhat Khairallah
15. Scott & White Memorial Hospital (Temple, TX) – Dr. Taresh Taneja
16. Geisinger Wyoming Valley Medical Center (Wilkes-Barre, PA) – Dr. Gopi Dandamudi
17. Provena St. Joseph Medical Center (Joliet, IL) – Dr. Ahmad Karim
18. Lankenau Institute for Medical Research (Wynnewood, PA) – Dr. Douglas Esberg
19. St. Mary Medical Center (Newtown, PA) – Dr. Scott Burke
20. Wellmont Holston Valley Medical Center (Kingsport, TN) – Dr. Gregory Jones
21. The Methodist Hospital Research Institution (Houston, TX) – Dr. Tapan Rami
22. Northeast Georgia Heart Center, PC (Gainesville, GA) – Dr. Salem Sayar
23. Hackensack University Medical Center (Hackensack, NJ) – Dr. Gunjan Shukla
24. Sentara Norflok General Hospital (Norfolk, VA) – Dr. Philip Gentlesk
25. Covenant Medical Center (Saginaw, MI) – Dr. Asim Yunus
26. Northeast Baptist Hospital (San Antonio, TX) – Dr. Stephen Reich