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Hearing loss and cognitive decline among older adults with atrial fibrillation: the SAGE-AF study

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Abstract

Objective To examine the association between hearing loss and cognitive function cross-sectionally and prospectively among older adults with atrial fibrillation (AF). **Methods** Patients with AF ≥ 65-year-old (n = 1244) in the SAGE (Systematic Assessment of Geriatric Elements)-AF study were recruited from five internal medicine or cardiology clinics in Massachusetts and Georgia. Hearing was assessed by a structured questionnaire at baseline. Cognitive function was assessed by Montreal Cognitive Assessment (MoCA) at baseline and one year. Cognitive impairment was defined as score ≤ 23 on the MoCA. The associations between hearing loss and cognitive function were examined by multivariable adjusted logistic regression. **Results** Participants with hearing loss (n = 451, 36%) were older, more likely to be male, and have depressive symptoms than patients without hearing loss. At baseline, 528 (42%) participants were cognitively impaired. Individuals with hearing loss were significantly more likely to have cognitive impairment at baseline [adjusted odds ratio (OR) = 1.37, 95% confidence interval (CI): 1.05–1.81]. Among the 662 participants who did not have cognitive impairment at baseline and attended the one-year follow-up visit, 106 (16%) developed incident cognitive impairment. Individuals with, versus those without, hearing loss were significantly more likely to develop incident cognitive impairment at one year (adjusted OR = 1.68, 95% CI: 1.07–2.64). **Conclusions** Hearing loss is a prevalent but under-recognized factor associated with cognitive impairment in patients with AF. Assessment for hearing loss may be indicated among these patients to identify individuals at high-risk for adverse outcomes.

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1 Introduction

Atrial fibrillation (AF) is the most common cardiac arrhythmia with an increasing prevalence among older Americans.[1,2] Recently, AF has been associated with an increased risk of cognitive decline.[3,4] This is thought to be due to the occurrence of clinical strokes, subclinical embolic brain infarcts, and a high prevalence of other vascular risk factors associated with cognitive decline among patients with AF.[5,6] However, the association between AF and cognitive decline is incompletely explained by these factors.[7]

Moreover, most studies examining the association between AF and cognitive decline have not considered the impact of non-cardiovascular conditions, which are risk factors for cognitive decline and are common in older men and women. Hearing loss is prevalent among the older as more than one-half of Americans > 70 years have hearing loss.[8] It is also independently associated with poor cognition[9] and accelerated cognitive decline[10] in the older. We previously reported a very high prevalence of hearing loss among older patients with AF,[11] and now speculate that older patients with AF with concomitant hearing loss are particularly vulnerable to cognitive decline. If this is true, screening for hearing loss among older patients with AF followed by hearing rehabilitative therapy may be worth testing in future studies to see whether it affects the trajectory of their cognitive function. Currently, the United States Preventive Services Task Force does not endorse screening for hearing loss in the older given incomplete evidence.[12]

The SAGE (Systematic Assessment of Geriatric Ele-

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ments)-AF study is an ongoing, prospective study enrolling patients with AF ≥ 65-year-old in whom serial comprehensive examinations of geriatric conditions, including hearing and cognitive function, were performed. This provides a unique and timely opportunity to examine the association between hearing loss and cognitive function in older men and women with AF.

2 Methods

2.1 Study population

The SAGE-AF cohort has been previously described.[13] In brief, the eligibility criteria include: (1) patients have an ambulatory visit at one of four Central Massachusetts practices (University of Massachusetts Memorial Health Care Internal Medicine, Cardiology, or Electrophysiology, Heart Rhythm Associates of Central Massachusetts), one practice in Eastern Massachusetts (Boston University Cardiology), or two practices in Central Georgia (Family Health Center and Georgia Arrhythmia Consultants); (2) AF is present on an electrocardiogram or Holter monitor or if it is noted in any clinic note or hospital record); (3) patients be aged 65 years or older; and (4) patients have a CHA_2DS_2-VASc[14] risk score ≥ 2. Participants are not eligible if they have an absolute contraindication to the receipt of oral anticoagulation, if they have an indication for oral anticoagulation other than AF (*i.e.*, mechanical heart valve), if they cannot provide informed consent, if they do not speak English, if they have a planned invasive high bleeding risk procedure, if they are prisoners, or if they are unwilling or unable to participate in planned one- and two-year follow-up visits.

A total of 1244 participants completed their baseline examination. A follow-up visit was performed one year after study baseline enrollment. All participants provided informed written consent. Study protocols were approved by the University of Massachusetts Medical School, Boston University, and Mercer University Institutional Review Boards.

2.2 Data collection

Data on eligible and consenting patient's demographic and clinical characteristics were abstracted from the medical record by trained study staff. Information abstracted included participants' age, sex, race, insurance type, comorbidities relevant to stroke and bleeding risk (e.g., diabetes, hypertension, heart failure, anemia, chronic kidney disease), and cardiovascular treatments (*i.e.*, use of anti-platelets).

2.3 Hearing assessment

Hearing was assessed by three questions. (A) "Do you wear a hearing aid?" Response options are "Yes" or "No"; (B) "Do you have a hearing problem now? If you use a hearing aid, please answer the way you hear with a hearing aid." Response options are "Yes" or "No"; and (C) "How much does your hearing interfere with your activities? If you use a hearing aid, please answer the way you hear WITH a hearing aid." Response options include "Not a lot", "A little", "A moderate amount", or "A lot". A participant was characterized as having hearing loss if he/she answered "Yes" to questions (A) or (B), or "a moderate amount" or "A lot" to question (C).

2.4 Cognitive function assessment

Cognitive function was assessed by the Montreal Cognitive Assessment Battery (MoCA),[15] a 30-item screening tool validated to detect mild cognitive impairment. The MoCA test examines global cognitive function with assessments for memory, visuospatial ability, executive function, attention, concentration, working memory and orientation. Scores range from 0–30 with lower scores indicating poorer performance. The MoCA test was performed at baseline and one year later. Cognitive impairment was defined as a score ≤ 23.[16]

Because hearing loss may affect test performance on the MoCA, we also used the MoCA-auditory scoring which removes the three MoCA items heavily relying on hearing: language repetition (2 points), attention to letters (1 point), and digit span (2 points). After removal, the maximum MoCA score becomes 25, and the revised cutoff score for a "normal" score is 21/25 with 22/25 needed to pass).[17,18] Because there is no consensus as to what constitutes a clinically meaningful difference in MoCA score, we chose not to examine MoCA as a continuous variable.

2.5 Frailty and depression assessment

Frailty is assessed using the Cardiovascular Health Survey frailty scale.[19] It has five components: weight loss/shrinking, exhaustion, low physical activity, slow gait speed, and weakness. Each component receives a point and the scale ranges from 0–5. A participant is considered to be frail if three or more criteria are present, pre-frail (1–2), and not frail (0). The Patient Health Questionnaire (PHQ-9) was used to assess for depressive symptoms[20] with a score ≥ 5 indicating high depressive symptoms.

2.6 Statistical analysis

Baseline characteristics of study participants were compared according to hearing status using analysis of variance for continuous variables and the χ^2 test for categorical variables.

For the cross-sectional analysis, the association between hearing loss and cognitive impairment was examined by logistic regression. For the prospective analysis, among participants without baseline cognitive impairment, the association between baseline hearing loss and incident cognitive impairment at one-year follow-up was also examined by logistic regression modelling. In regression Model 1, we controlled for age, sex, race, and education. In Model 2, we additionally adjusted for diabetes, hypertension, and stroke. Lastly, Model 3 further adjusted for the receipt of an oral anticoagulant agent.

To evaluate the health-related effects of wearing a hearing aid, we created a second definition of hearing loss. For this definition, individuals who only responded "Yes" to question (A) were not counted as having hearing loss. Only those who reported trouble hearing and/or those who say hearing problems interfere with daily activities are included. We adjusted for this variable in this manner, because simply adjusting for the use of a hearing aid may not have been adequate given the structure of our questionnaire.

Statistical analyses were performed using SAS 9.4 (SAS Institute, Inc., Cary, North Carolina, USA). A two-sided *P*-value < 0.05 was considered to be statistically significant.

3 Results

The 1224 study participants were, on average, 75.8 ± 6.9 years, 49% were women, and 84.9% were non-Hispanic white. A total of 1065 patients (86%) were prescribed an anticoagulant and 179 were not treated with anticoagulants based on either their personal preference or at the discretion of the treating physician. Hearing loss was prevalent and reported by 451 (36.3%) participants at baseline. Individuals with hearing loss were significantly older and less likely to be female. Stroke, depression, peripheral artery disease, and use of implantable cardiac device were more prevalent among individuals with, as compared to those without, hearing loss (Table 1).

At baseline, 528 (42%) participants scored ≤ 23 on the MoCA, indicating the presence of at least mild cognitive impairment. Cross-sectionally, individuals with hearing loss were significantly more likely to be cognitively impaired [50% *vs.* 38%, odds ratio (OR) = 1.61, 95% confidence interval (CI): 1.28–2.03]. This association remained significant and only slightly attenuated after adjusting for demographic characteristics, education, vascular risk factors for cognitive impairment, and anticoagulation therapy (adjusted OR = 1.37, 95% CI: 1.05–1.81) (Table 2).

Among the 662 participants who did not have cognitive impairment at baseline and attended the one-year follow-up visit, 106 (16%) developed at least mild cognitive impairment over this period. Individuals with hearing loss were significantly more likely to develop cognitive impairment at one year (21% *vs.* 14%, OR = 1.70, 95% CI: 1.11–2.60). This association remained essentially unchanged after adjusting for previously described potentially confounding factors of importance (Table 3).

We built an additional model of age, gender, CHA_2DS_2-VASc, and depression. In this model, the OR (95% CI) for prevalent cognitive impairment of hearing loss was 1.17 (0.91–1.51). The OR (95% CI) for incident cognitive impairment of hearing loss was 1.48 (0.95–2.31).

When hearing loss was defined by the criteria not including the use of hearing aid, the results did not change substantially. The cross-sectional association between hearing loss and baseline cognitive impairment was not statistically significant, though elevated (adjusted OR = 1.31, 95% CI: 0.98–1.74). Hearing loss remained significantly associated with the development of new onset cognitive impairment during our one-year follow-up (adjusted OR = 1.63, 95% CI: 1.02–2.60) (supplemental material, Table 1S & Table 2S).

When the auditory MoCA was used, hearing loss was associated with prevalent cognitive decline (47% *vs.* 38%, OR = 1.40, 95% CI: 1.11–1.77). The association was not, however, statistically significant after multivariable adjustment (adjusted OR = 1.13, 95% CI: 0.87–1.48). Prospectively, incident cognitive impairment was more common in participants with hearing loss (22% *vs.* 16%, adjusted OR = 1.53, 95% CI: 0.97–2.40) (supplemental material, Table 3S & Table 4S).

4 Discussion

Among older adults with AF seen in the ambulatory setting, we demonstrated that self-reported hearing loss and cognitive impairment are both prevalent, affecting 36% and 42% of individuals, respectively. Individuals with hearing loss were 60% more likely to have concomitant cognitive impairment and, more strikingly, were 70% more likely to develop cognitive impairment during the one-year follow-up.

Multiple prospective and cross sectional studies have suggested that AF is a risk factor for cognitive impairment, cognitive decline, and dementia.[3,7,21] While the underlying mechanisms are likely multifactorial, clinical strokes and subclinical embolic brain infarcts are speculated as the main contributing factors.[5,6] In addition, cerebral hypoperfusion in the absence of clinical low output heart failure could play a role.[22] It has also been proposed that the association may

Table 1. Characteristics of older adults with atrial fibrillation by self-reported hearing status.

Characteristic	Hearing loss		*P*-value
	Yes (*n* = 451)	No (*n* = 793)	
Age, yrs	77.9 ± 7.5	74.2 ± 6.5	< 0.01
65–74	169 (37.5%)	457 (57.6%)	
75–84	183 (40.6%)	271 (34.2%)	< 0.01
85 or older	99 (22.0%)	65 (8.2%)	
Female	200 (44.4%)	407 (51.3%)	0.02
Non-Hispanic white	398 (88.3%)	658 (83.0%)	0.01
Education			
< = High school graduate	32 (7.3%)	68 (8.7%)	
Some college	218 (50.0%)	375 (48.0%)	0.81
College graduate or above	189 (43.1%)	338 (43.2%)	
Income, $			
Less than 10,000	18 (4.9%)	34 (5.1%)	
10,000–49,999	181 (48.9%)	291 (43.5%)	0.21
50,000–99,999	102 (28.4%)	227 (33.9%)	
More than100,000	66 (17.9%)	117 (17.5%)	
Insurance			
Commercial/HMO/PPO	74 (15.9%)	151 (18.9%)	0.23
Medicare	334 (74.1%)	564 (71.1%)	
Frailty			
Not frail	135 (29.9%)	278 (35.1%)	
Frail	63 (14.0%)	109 (13.8%)	0.17
Pre-frail	253 (56.1%)	406 (51.2%)	
CHA_2DS_2-VASc score	4.7 ± 1.6	4.3 ± 1.6	< 0.01
Smoking			
Never	212 (47.0%)	382 (48.2%)	
Former	224 (49.7%)	391 (49.3%)	0.69
Current	15 (3.3%)	20 (2.5%)	
Alcohol abuse/dependency	133 (29.5%)	251 (31.7%)	0.43
Medical history			
Heart failure	177 (39.3%)	286 (36.1%)	0.26
Carotid disease	57 (12.6%)	76 (9.6%)	0.09
Coronary artery disease	91 (20.2%)	151 (19.0%)	0.62
Chronic renal disease	129 (28.6%)	227 (28.6%)	0.99
Peripheral vascular disease	77 (17.1%)	102 (12.9%)	0.04
Hypertension	410 (90.9%)	712 (89.8%)	0.52
Diabetes	117 (25.9%)	229 (28.9%)	0.27
Hyperlipidemia	364 (80.7%)	632 (79.7%)	0.67
Stroke	57 (12.6%)	65 (8.2%)	0.01
Implantable cardiac device	171 (37.9%)	250 (31.5%)	0.02
Medication			
Aspirin	161 (35.7%)	281 (35.4%)	0.93
Anticoagulant	386 (85.6%)	679 (85.6%)	
DOAC	157 (40.7%)	310 (45.6%)	0.11
Warfarin	229 (59.3%)	369 (54.3%)	
Depression	158 (35.0%)	195 (24.6%)	< 0.01
Anxiety	119 (26.4%)	174 (21.9%)	0.08

Data are presented as means ± SD or *n* (%). DOAC: direct oral anticoagulant; HMO: health maintenance organization; PPO: preferred provider organization.

Table 2. Association between hearing loss and prevalent cognitive impairment.

Hearing loss	Prevalent cognition impairment	OR (95% CI)			
		Unadjusted	Model 1	Model 2	Model 3
Yes (n = 451)	225 (50%)	1.61 (1.28–2.03)	1.38 (1.05–1.81)	1.38 (1.05–1.82)	1.37 (1.05–1.81)
No (n = 793)	302 (38%)	Reference			

Model 1: adjusted for age, sex, race, and education. Model 2: adjusted for variables in Model 1 plus diabetes, hypertension, and stroke. Model 3: adjusted for variables in Model 2 plus the receipt of anticoagulation. CI: confidence interval; OR: odds ratio.

Table 3. Association between hearing loss and incident cognitive impairment at one year.

Hearing loss	Incident cognitive impairment	OR (95% CI)			
		Unadjusted	Model 1	Model 2	Model 3
Yes (n = 208)	44 (21%)	1.70 (1.11–2.60)	1.65 (1.05–2.59)	1.68 (1.07–2.63)	1.68 (1.07–2.64)
No (n = 454)	62 (14%)	Reference			

Model 1: adjusted for age, sex, race, and education. Model 2: adjusted for variables in Model 1 plus diabetes, hypertension, and stroke. Model 3: adjusted for variables in Model 2 plus the receipt of anticoagulation. CI: confidence interval; OR: odds ratio.

be due to shared risk factors for cognitive decline and AF, including factors such as older age, hypertension, diabetes, smoking, and heart failure. However, adjusting for these shared risk factors does not fully explain the observed association.[21] Meanwhile, very few if any studies[21] examining cognitive decline in AF have considered non-cardiovascular risk factors for cognitive impairment. In this context, this is the first study examining the effect of hearing loss, a condition very common in the geriatric population, in relation to cognitive function in patients with AF.

Hearing loss has been associated with accelerated cognitive decline and incident cognitive impairment among older adults.[10] In 1984 older adults from the Health ABC study, individuals with hearing loss on audiometric testing had a 24% increase risk of incident cognitive impairment after six-year follow-up. Therefore, it is not surprising that the association was observed again in our AF population where the average age was 76 years old. What is striking is the high prevalence of hearing loss and cognitive impairment in this population. Because hearing loss was assessed by questionnaire instead of objective measurement, our study still likely underestimated the prevalence of hearing loss. It is possible that the questionnaire captures individuals with more severe hearing loss, because individuals with a milder form of this condition are more likely to underreport their hearing impairment.[23,24] Furthermore, rapid and significant cognitive decline in these individuals was observed after only one-year follow-up. Currently, hearing loss screening is not recommended in the older given the available lack of evidence.[12] Our study suggests that older adults with AF is a population in which hearing loss is very common and are vulnerable to cognitive decline. Therefore, hearing loss screening followed by application of hearing rehabilitative strategies may merit consideration in this population. Whether this approach reduces the rate of cognitive decline and improves quality of life in older individuals, irrespective of the presence of AF, deserves further research.[25]

Patients with AF often have multiple comorbidities. In addition to the presence of several cardiovascular diseases, conditions common in the geriatric population such as depression, anxiety, and frailty are also prevalent in older men and women with AF.[11,13,26,27] Traditionally, the three pillars of AF management are stroke prevention, rhythm control, and rate control. Recently, aggressive cardiovascular risk factor modification, including obesity and sleep apnea management, has emerged as the fourth pillar.[28] This finding, along with other work from our group,[13,29] highlighted not only hearing loss and cognitive decline, but also other highly prevalent geriatric conditions in patients with AF, such as depression and frailty. These conditions certainly deserve physicians' attention and we hope addressing them become the fifth pillar in the management of older individuals with AF. This approach is consistent with the recently proposed integrated or holistic approach in management of older patients with AF.[30]

We also speculate that the triad of hearing loss, cognitive impairment, and AF may present physician-patient communication challenges with potential implications for patient understanding AF and its management, including increased difficulties with medication and monitoring.

Furthermore, our finding suggests hearing loss can be a confounder in the association between AF and cognitive decline. Therefore, hearing loss and other conditions common in geriatric population deserve consideration in studying the mechanism of AF on cognitive function.

4.1 Strengths and limitations

This is the first study which systemically assessed physi-

cal, cognitive, and psychosocial conditions in patients with AF. Validated instruments were used to assess cognition, frailty, and mood. Also, the study population is geographically diverse and included patients with a high degree of comorbidities, emulating the real-world practice. Several limitations of this observational study need, however, to be kept in mind in its interpretation. Firstly, patient's hearing status was assessed by questionnaire and was not objectively measured. This approach likely underestimates the prevalence of hearing loss. On the other hand, objective hearing assessment requires expertise and can be time-consuming, which is not feasible in busy internal medicine or cardiology clinics. Secondly, the present follow up was for only one year, which likely underestimates the association between hearing loss and cognitive function among patients followed for longer periods of time. One possible risk factor for cognitive decline in elderly individuals is nocturnal blood pressure. We do not have that measured in the study. However, we used hypertension abstracted from the medical record and adjusted it in the models. Last but not least, we attempted to assess the effects of wearing a hearing aid by creating two definitions of hearing loss (including and excluding hearing aid). However, hearing treatment is complex and patients using a hearing aid may be significantly different in many ways from those not using such a device, medically and socioeconomically.[10] Therefore, future studies are required to clarity the effect of use of hearing aids on cognitive function among older men and women with AF.

4.2 Conclusions

Hearing loss is a prevalent, easily assessed, and under-recognized factor associated with cognitive impairment in patients with AF. Hearing loss is independently associated with prevalent cognitive impairment cross-sectionally and incident cognitive impairment after one-year follow-up. Screening for hearing loss may be indicated among older patients with AF to identify individuals at high-risk for adverse outcomes. Assessment of hearing and other conditions common in geriatric population merits consideration in future studies on the association between AF and cognitive impairment.

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