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ORIGINAL ARTICLE
Medical Economy

Cost-Effectiveness of Obstructive Sleep Apnea Screening and Treatment Before Catheter Ablation for Symptomatic Atrial Fibrillation

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Background: Although management of obstructive sleep apnea (OSA) has been recommended to improve outcomes of catheter ablation (CA) in patients with symptomatic atrial fibrillation (AF), the most cost-effective way of preprocedural OSA screening is undetermined. This study assessed the cost-effectiveness of OSA management before CA for symptomatic AF.

Methods and Results: A Markov model was developed to assess the cost-effectiveness of 3 OSA detection strategies before CA: no screening; Type 3 portable monitor (PM)-guided screening; and polysomnography (PSG)-guided screening. The target population consisted of a hypothetical cohort of patients aged 65 years with symptomatic AF, with 50% prevalence of OSA. We used a 5-year horizon, with sensitivity analyses for significant variables and scenario analyses for lower and higher OSA prevalence (30% and 70%, respectively). In the base-case, both types of OSA screening were dominant (less costly and more effective) relative to no screening. Although PSG-guided management was more effective than PM-guided management, it was more costly and therefore did not show clear benefit. These findings were replicated in cohorts with lower and higher OSA risks.

Conclusions: OSA screening before CA is cost-effective in patients with symptomatic AF, with PM screening being the most cost-effective. Physicians should consider OSA management using this simple tool in the decision making for treatment of symptomatic AF.

Key Words: Atrial fibrillation; Catheter ablation; Continuous positive airway pressure ventilation; Cost-effectiveness; Obstructive sleep apnea

Atrial fibrillation (AF) is the most common arrhythmia, and its increasing incidence has contributed to rising healthcare costs all over the world.[1–3] Although catheter ablation (CA) has become well established as an effective therapy for AF, recurrence of AF is still common despite advances in technology and procedural techniques.[4–7] Obstructive sleep apnea (OSA) is a well-known risk factor for AF, and is associated with recurrence after CA for AF.[8,9] The effectiveness of continuous positive airway pressure (CPAP) therapy for OSA has been widely accepted, and recent studies demonstrated that CPAP therapy can improve outcomes of CA for AF in patients with OSA.[10,11] Based on this evidence, recent guidelines emphasize the importance of screening and optimal treatment for OSA in patients with AF.[12,13] Nonetheless, screening for OSA before CA for AF remains inconsistent in "real-life" clinical practice. In addition, no study has evaluated the cost-effectiveness of different OSA screening strategies in patients who elect to undergo CA for symptomatic AF. Thus, the aim of the present study was to assess the cost-effectiveness of preprocedural OSA screening in patients who elect to undergo CA for symptomatic AF. Further, we compared the cost-effectiveness of different OSA screening strategies between a full-channel polysomnography (PSG)

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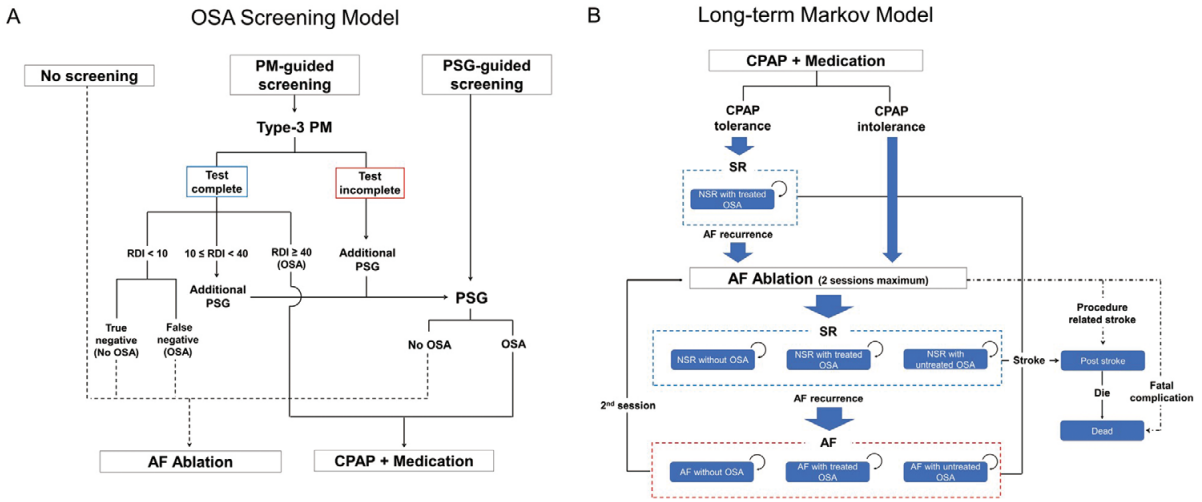

Figure 1. Decision model for comparing 3 approaches to obstructive sleep apnea (OSA) screening in patients with symptomatic atrial fibrillation (AF). (**A**) Structure of the OSA screening model. (**B**) Structure of the long-term Markov model. CPAP, continuous positive airway pressure; NSR, normal sinus rhythm; PM, portable monitor; PSG, polysomnography; RDI, respiratory disturbance index; SR, sinus rhythm.

and a Type 3 portable monitor (PM), which has been widely used for screening of OSA.

Methods

We developed economic models to assess the cost-effectiveness of OSA management strategies in patients who elect to undergo CA for symptomatic AF. Model building and analyses were performed using TreeAge Pro 2019 (TreeAge Software, Williamstown, MA, USA). The model evaluated costs and quality-adjusted life years (QALY) from the Japanese health system perspective for each strategy. The time horizon of the model was 5 years, with a cycle length of 6 months. Half-cycle correction was applied and discounting at 2% was performed annually for both costs and QALYs.

Primary outcomes were evaluated using incremental cost-effectiveness ratios (ICERs), calculated by dividing the incremental costs by the incremental effectiveness. The willingness-to-pay (WTP) threshold of 5,000,000 Japanese yen (JPY) per QALY was applied based on previous studies.[14,15]

The present study was conducted according to the Consolidated Health Economic Evaluation Reporting Standards (CHEERS) statement and the Japanese guidelines for the economic evaluation of drugs and medical devices in Japan.[15,16] The CHEERS checklist is given in the Supplementary Material (the last table).

Decision Model

The target population consisted of a hypothetical cohort of Japanese patients aged 65 years with symptomatic AF and a $CHADS_2$ score of 2. In the base cohort, the proportion of patients with OSA and non-paroxysmal AF was assumed to be 50% and 33%, respectively, based on our previous study.[17] A simplified presentation of the model structure and patient pathway are shown in **Figure 1**.

OSA Screening The management strategies for OSA screening, as shown in **Figure 1A**, were: (1) no screening, whereby all patients undergo their first CA without OSA screening and treatment; (2) PSG-guided screening, whereby all patients undergo screening for OSA with a standard overnight full-channel PSG (the gold standard test for the diagnosis of OSA)[18] before the first CA; and (3) PM-guided screening, whereby all patients undergo screening for OSA with a Type 3 PM at home before the first CA.

Type 3 PM studies use devices that measure limited cardiopulmonary parameters: 2 respiratory variables (e.g., effort to breathe, airflow), oxygen saturation, and a cardiac variable (e.g., heart rate or electrocardiogram [ECG]).[18] The diagnosis of OSA is based on the respiratory disturbance index (RDI), which is defined as the number of apneas and hypopneas per hour of the analyzed time length;[19] patients with an RDI ≥40 would be diagnosed as having OSA, whereas those with an RDI <10 would be diagnosed as having a low risk of OSA, and proceed to the first CA without additional tests. Patients with 10≤RDI<40 would be diagnosed as being at moderate risk of OSA, and an additional PSG would be performed. An incomplete PM test would lead to additional PSG.

AF Treatment Strategy and Long-Term Markov Model Patients diagnosed as having OSA would add CPAP therapy to medication (rhythm and rate control) before CA (**Figure 1B**). If AF could be suppressed by CPAP and medication, these therapies would be continued without CA. However, CA would be performed if AF recurred or patients were intolerant to CPAP. All patients were allocated to 1 of 8 health states: normal sinus rhythm (NSR) without OSA; NSR with treated OSA; NSR with untreated OSA; AF without OSA; AF with treated OSA; AF with untreated OSA; after stroke; and dead. Patients could experience clinical events leading to disability and death and could incur associated costs and QOL adjustments.

Transition Probabilities

All transition probabilities were obtained from the literature

Table 1. Values for Transition Probabilities, Utilities, and Costs

Variable	Base value	Minimum	Maximum	PSA distribution	References
Event probabilities					
AF					
Proportion of non-PAF (%)	33.0	0	100	Triangular (Min 0, Likeliest 33.0, Max 100)	17
AF recurrence after first ablation					
PAF (%/year)					
≤1 year	27.6	20.8	34.6	β (SD=2.82)	5, 6
>1 year	3.2	2.4	4.0	β (SD=0.33)	5, 6
Non-PAF (%/year)					
≤1 year	39.2	36.8	50.0	β (SD=2.87)	5, 7
>1 year	5.2	5.0	5.2	β (SD=0.05)	5, 7
AF recurrence after second ablation					
PAF (%/year)					
≤1 year	8.8	6.6	11.0	β (SD=0.90)	5, 6
>1 year	2.0	1.6	2.6	β (SD=0.21)	5, 6
Non-PAF (%/year)					
≤1 year	16.4	15.6	20.0	β (SD=0.96)	5, 7
>1 year	3.8	3.4	5.0	β (SD=0.34)	5, 7
Relative risk of AF recurrence					
No OSA vs. untreated OSA	1.4	1.05	1.75	Log-normal (σ=0.0378)	20
No OSA vs. treated OSA	1.1	1.00	1.38	Log-normal (σ=0.0013)	20
AF ABL vs. CPAP+medication	0.86	0.54	1.38	Log-normal (σ=0.3086)	21
Probability of second session (%)	75.7	73.1	80.9	β (SD=3.24)	5–7
Probability of complications (%/ABL)					
Cardiac tamponade	0.9	0.9	3.3	β (SD=0.50)	22
Stroke	0.2	0.1	0.3	β (SD=0.08)	22
AV fistula/pseudoaneurysm	0.1	0.1	0.42	β (SD=0.05)	22, 23
Fatal complication	0.05	0.0	0.1	β (SD=0.015)	22–24
Stroke events					
$CHADS_2$ score of 2 without OAC (%/year)	1.5	0.96	2.50	β (SD=0.32)	30
Relative risk of stroke					
No OAC vs. OAC	0.36	0.26	0.51	Log-normal (σ=0.0746)	31
NSR vs. AF	2.51	1.37	4.62	Log-normal (σ=0.0894)	32
Mortality after stroke (%/year)					
≤1 year	32.6	27.6	37.4	β (SD=2.00)	33
>1 year	12.2	12.0	12.2	β (SD=0.08)	33
Utilities					
NSR without OSA	0.790	0.593	0.988	Triangular (Min 0.593, Likeliest 0.790, Max 0.988)	34
NSR with treated OSA	0.743	0.557	0.929	Triangular (Min 0.557, Likeliest 0.743, Max 0.929)	34, 35
NSR with untreated OSA	0.679	0.509	0.849	Triangular (Min 0.509, Likeliest 0.679, Max 0.849)	34, 35
AF without OSA	0.725	0.544	0.906	Triangular (Min 0.544, Likeliest 0.725, Max 0.906)	34
AF with treated OSA	0.682	0.512	0.857	Triangular (Min 0.512, Likeliest 0.682, Max 0.857)	34, 35
AF with untreated OSA	0.624	0.468	0.780	Triangular (Min 0.468, Likeliest 0.624, Max 0.780)	34, 35
Post stroke	0.52	0.39	0.65	Triangular (Min 0.39, Likeliest 0.52, Max 0.65)	36
Dead	0	0	0	NA	
One-time decrement for procedural complication	−0.10	−0.12	−0.08	NA	37, 38
One-time decrement for stroke	−0.139	−0.174	−0.104	NA	37, 38

(**Table 1** continued the next page.)

Variable	Base value	Minimum	Maximum	PSA distribution	References
Costs					
One-time cost (JPY/test, procedure, or event)					
OSA screening					
Type 3 PM-guided screening					
Type 3 PM only	10,750	10,750	18,680	Triangular (Min 10,750, Likeliest 10,750, Max 18,680)	39
Type 3 PM+PSG	121,480	121,480	129,410	Triangular (Min 121,480, Likeliest 121,480, Max 129,410)	39, 40
PSG-guided screening	113,550	113,550	121,480	Triangular (Min 113,550, Likeliest 113,550, Max 121,480)	39, 40
AF ablation					
First session	2,022,300	1,845,300	2,132,300	γ (SD=118,227)	17, 39, 40
Second session	2,013,500	1,836,500	2,123,500	γ (SD=118,227)	17, 39, 40
Complication of cardiac tamponade	271,000	175,800	366,200	γ (SD=77,730)	39, 40, estimate
Complication of AV fistula/pseudoaneurysm	1,836,400	1,300,000	2,300,000	γ (SD=408,608)	39, 40, estimate
Fatal complication	6,464,320	4,800,000	8,100,000	γ (SD=1,347,236)	39, 40, estimate
Stroke events	1,192,099	894,074	1,490,124	γ (SD=243,336)	32
Annual cost (JPY/year)					
AF follow-up	46,920	19,060	46,920	γ (SD=6,567)	39
Medication					
OAC	199,290	107,280	199,290	Triangular (Min 107,280, Likeliest 199,290, Max 199,290)	41
Rhythm and rate control	44,531	17,703	101,106	Triangular (Min 17,703, Likeliest 44,531, Max 101,106)	41
CPAP therapy	162,000	162,000	162,720	Triangular (Min 162,000, Likeliest 162,000, Max 162,720)	39
Post-stroke care	3,974,592	3,285,780	4,663,404	γ (SD=344,406)	42

AF, atrial fibrillation; CPAP, continuous positive airway pressure; Min, minimum; Max, maximum; OAC, oral anticoagulation; OSA, obstructive sleep apnea; PM, portable monitor; PAF, paroxysmal atrial fibrillation; PSA, probabilistic sensitivity analysis; PSG, polysomnography.

Table 2. Setting and Results of OSA Screening and the Probability of CPAP Intolerance in Each Cohort

	OSA prevalence		
	30% (low-risk cohort; scenario analysis)	50% (base cohort; main analysis)	70% (high-risk cohort; scenario analysis)
Type 3 PM results			
RDI <10 (%)	40.8	28.0	22.4
10≤RDI<40 (%)	52.8	64.0	56.8
RDI ≥40 (%)	6.4	8.0	20.8
Probability of false negative in patients with RDI <10 (%)	1.0 (range 1.0–5.0)	2.5 (range 1.0–5.0)	5.0 (range 1.0–5.0)
Probability of data incomplete (%)	10.3 (range 2.5–18)		
CPAP intolerance (%)	36.0 (range 17.0–54.0)		

RDI, respiratory disturbance index. Other abbreviations as in Table 1.

and expert sources (**Table 1**).

AF Recurrence The probability of AF recurrence was judged according to the type of AF (paroxysmal or non-paroxysmal AF), the number of CA, and the presence or absence of OSA and/or CPAP.[5–7,20] We selected Japanese studies as the source of transition probability regarding AF treatment as much as possible. We assumed that 75.7% of patients with AF recurrence after the first CA would have the second CA,[5–7] but we also anticipated the maximum number of CAs as 2, and patients with AF recurrence after the second CA would continue medication therapy (rhythm and rate control). The probability of AF recurrence in patients with CPAP and medication was based on a study comparing the effects of CA and CPAP for AF treatment.[21]

CA-Related Complications Our model included stroke, cardiac tamponade, arteriovenous fistula, pseudoaneurysm, and fatal complication as periprocedural adverse events. The frequency of these complications was obtained from the literature.[22–24]

Sleep Study The proportion of OSA and results of Type 3 PM in the base cohort were estimated based on our previous study (**Table 2**).[17] The accuracy of PSG was

Table 3. Deterministic Cost-Effectiveness Results for 3 OSA Screening Strategies Before Catheter Ablation for Symptomatic AF

Strategy	Total costs (JPY)	Total QALYs	ICER (JPY/QALY) vs. no screening	ICER (JPY/QALY) vs. PM-guided screening
Base cohort (OSA 50%)				
No screening	3,959,246	6.50083		
PM-guided screening	3,703,510	6.68912	Dominant	
PSG-guided screening	3,725,999	6.69151	Dominant	9,804,082

ICER, incremental cost-effectiveness ratio; JPY, Japanese yen; QALY, quality-adjusted life-year. Other abbreviations as in Tables 1,2.

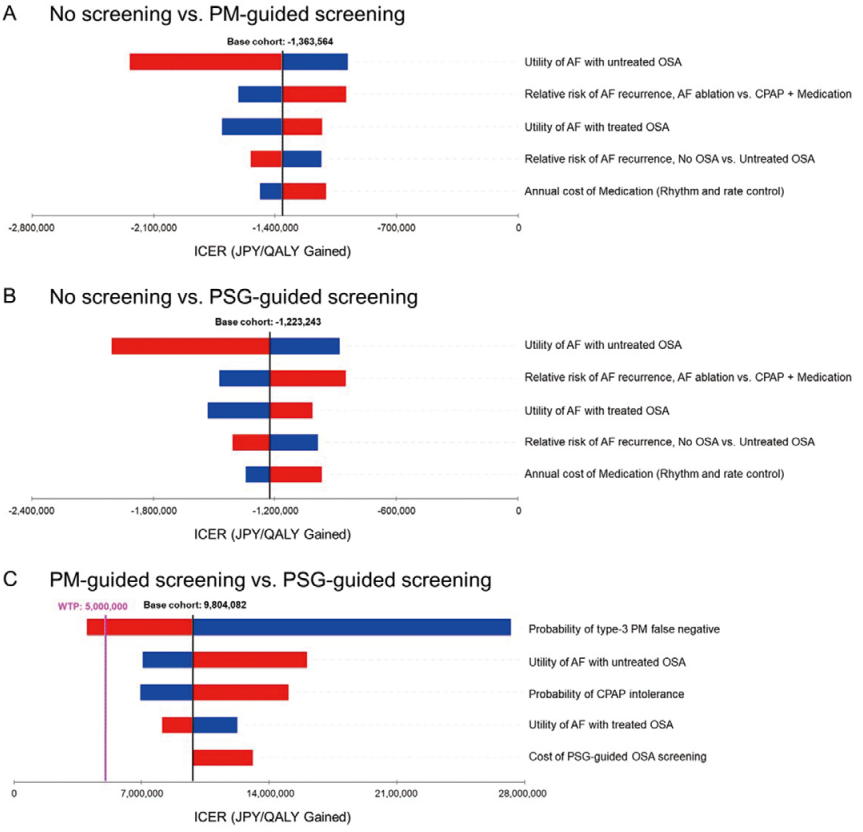

Figure 2. Deterministic sensitivity analyses. Tornado diagrams demonstrating the effects of cost, utilities and transition probabilities on expected value, assuming a willingness-to-pay (WTP) value of 5,000,000 JPY. Variables and ranges used in the analysis are described in **Table 1**. (**A**) No screening vs. portable monitor (PM)-guided screening; (**B**) no screening vs. polysomnography (PSG)-guided screening; and (**C**) PM- vs. PSG-guided screening. AF, atrial fibrillation; CPAP, continuous positive airway pressure; ICER, incremental cost-effectiveness ratio; OSA, obstructive sleep apnea; QALY, quality-adjusted life years.

assumed to be 100%. We anticipated that patients undergoing PM could have test failure or false-negative results because of performance of PM tests at home and under unattended situations.[19,25–28] The probability of CPAP intolerance was assumed to be 36%.[29]

Stroke Event The annual probability of stroke in patients with AF and a $CHADS_2$ score of 2 but without oral anticoagulation (OAC) was derived as 1.5% from a large Japanese registry,[30] and this risk was multiplied by a relative risk of 0.36, based on the relative efficacy of OAC.[31] We anticipated a 2.7-fold higher stroke risk in AF compared with NSR.[32] Mortality after stroke was estimated to be 32.6% during the first 1 year, and 12.2% per year thereafter.[33]

Utilities

Utility weights were multiplied by the duration in each health state to calculate QALYs. The QALY was calculated by the QOL score, which regards perfect health as 1 and death as 0. Based on previous studies, we set the QOL for each state (**Table 1**).[34–36] In addition, disutilities, one-time decrements to QOL, were applied to account for acute events, including complication and stroke (**Table 1**).[37,38]

Costs

The cost analysis was taken from the perspective of the healthcare provider using direct medical costs for the therapies, as well as costs for long-term disability care. Societal costs (e.g., costs of transportation, temporary leave from work, and family nursing care) were not considered in this study. The unit prices for each medical procedure and medication were obtained from the Japanese government-regulated medical price schedule.[39–41] The costs published in the literature were corrected for intervening currency

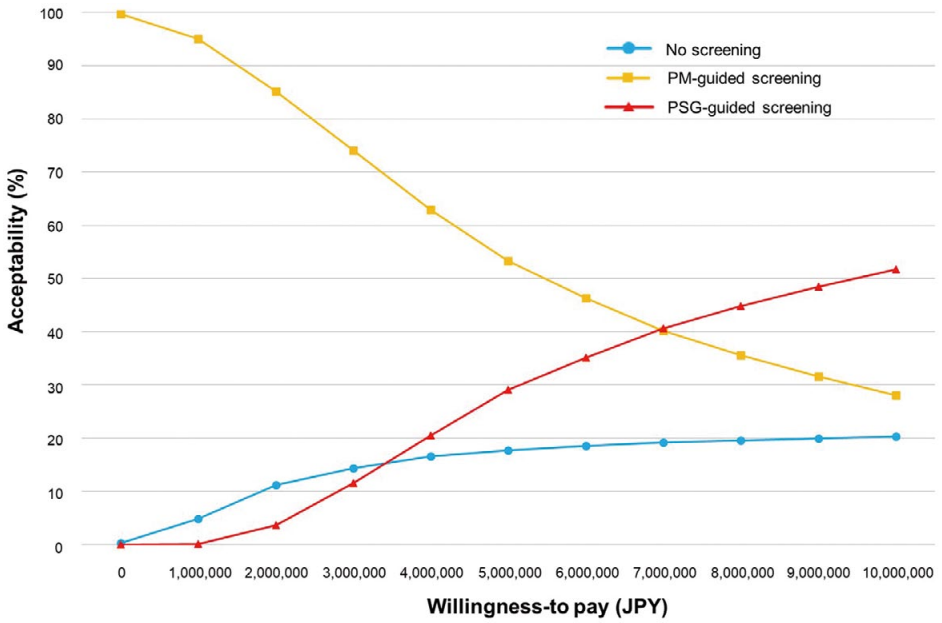

Figure 3. Cost-effectiveness acceptability curves representing the probability that each obstructive sleep apnea screening is cost-effective for a given maximum willingness-to-pay threshold per quality-adjusted life year gained in patients who elect to undergo catheter ablation for symptomatic atrial fibrillation. PM, portable monitor; PSG, polysomnography.

fluctuations, and costs were expressed to 2019 JPY. The details of costs are summarized in **Table 1** and **Supplementary Table 1**. The cost of each OSA management was estimated from the standard cost in our facility (Ehime University Hospital). The cost of each ablation procedure was estimated based on a standard method using radiofrequency irrigated catheters and 3-dimensional electroanatomic maps.[17] The annual cost of AF follow-up was based on a Holter ECG, a transthoracic echocardiogram, and 12-lead ECGs. The cost of medications varied depending on the results of AF treatments. Patients who had AF recurrence would undergo rhythm and rate control with flecainide and bisoprolol. We expected that OAC therapy continued in all patients regardless of rhythm, because our target population had a $CHADS_2$ score of 2. OAC therapy was defined as the usual daily dose of new OACs (NOACs). The cost of an acute stroke event and post-stroke disability care were based on previous studies.[32,42]

Sensitivity Analyses

We performed both deterministic and probabilistic sensitivity analyses to identify how changes in parameters incorporated in the model affected the outputs. In deterministic sensitivity analysis, 1-way sensitivity analyses, under which parameters were varied one by one, were performed to identify the critical sources of variation in the input data. The ranges for each parameter are summarized in **Table 1**. In general, ranges for parameters were varied within 95% confidence intervals (CIs), where available, and by ±25% or from minimum to maximum of the literature where CIs were not available.

In probabilistic sensitivity analysis (PSA), Monte Carlo simulations were performed on a hypothetical 10,000 patient cohort to examine the effect of parameter uncertainty in the frequency of probabilities, utilities, and costs. Parameters were assigned a distribution in the PSA where appropriate (**Table 1**). The β distribution was assigned for binomial outcomes, where parameters can vary between 0 and 1, for example probabilities. The gamma distribution was assigned for costs where parameters are non-negative. The log-normal distribution was chosen for relative risks. Multiple parameters were varied simultaneously in the PSA.

Scenario Analyses

To determine the applicability of cost-effectiveness of the OSA management before CA for AF under different circumstances, additional scenario analyses were conducted using the same Markov model. To evaluate the effect of OSA prevalence, the same analyses were performed using cohorts with low (OSA prevalence 30%) and high (OSA prevalence 70%) OSA risk. Parameters for the scenario analyses are summarized in **Table 2**.

Results

Base Cohort Analysis

The results of cost-effectiveness analyses in the base cohort are summarized in **Table 3**. Both methods of OSA screening were dominant (i.e., less costly and more effective) relative to no screening. Although PSG-guided screening was more effective than PM-guided screening, it was more costly and therefore did not show clear benefit. Based on the results, PM-guided management was the most cost-effective therapeutic option for our target population.

Deterministic Sensitivity Analysis

The effects of main variations on outcomes are depicted in tornado diagrams showing the 5 most impactful variables

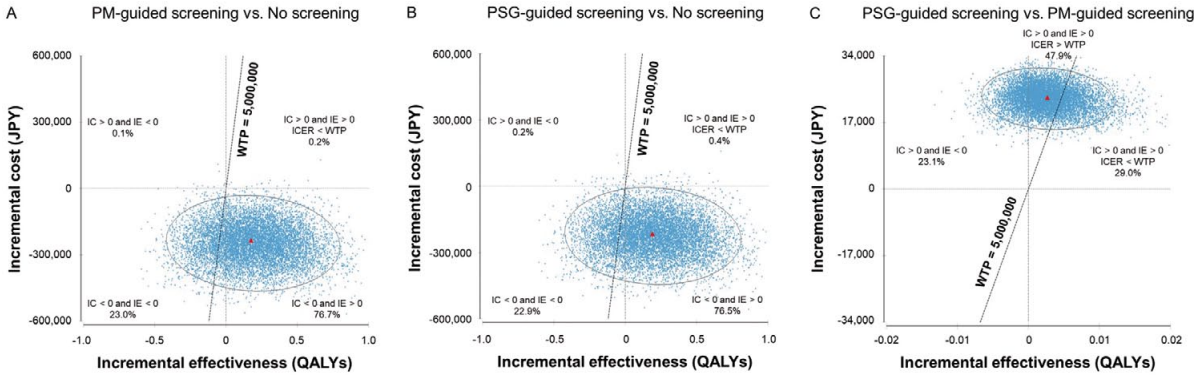

Figure 4. Incremental cost-effectiveness boot strap scatter plots in probability sensitivity analysis. (**A**) Portable monitor (PM)-guided screening vs. no screening; (**B**) polysomnography (PSG)-guided screening vs. no screening; and (**C**) PSG- vs. PM-guided screening. Red triangles indicate results for the base case and ellipses show the 95% confidence interval. IC, incremental cost; IE, incremental effectiveness; OSA, obstructive sleep apnea; QALY, quality-adjusted life years; WTP, willingness-to-pay value.

Table 4. Results of Scenario Analyses: Deterministic Cost-Effectiveness Results for 3 OSA Screening Strategies Before Catheter Ablation for Symptomatic AF Under Different OSA Prevalence

Strategy	Total costs (JPY)	Total QALYs	ICER (JPY/QALY) vs. no screening	ICER (JPY/QALY) vs. PM-guided screening
Low-risk cohort (OSA 30%)				
No screening	3,920,769	6.70303		
PM-guided screening	3,789,803	6.81604	Dominant	
PSG-guided screening	3,826,241	6.81744	Dominant	26,092,986
High-risk cohort (OSA 70%)				
No screening	3,997,723	6.29864		
PM-guided screening	3,597,728	6.56175	Dominant	
PSG-guided screening	3,625,758	6.56559	Dominant	7,312,106

Abbreviations as in Tables 1–3.

in descending order of influence (**Figure 2**). When comparing both types of OSA screening with no screening, results were most sensitive to variations in the utility of AF with untreated OSA (**Figure 2A**,**B**). However, both types of OSA screening remained dominant relative to no screening in all instances. When comparing PM-guided screening with PSG-guided screening, the variable that had the largest effect on outcomes was the probability of Type 3 PM false negative (**Figure 2C**). One-way sensitivity analysis of the probability of Type 3 PM false negative is shown in **Supplementary Figure 1**. Above the probability of 4%, PSG-guided screening would be more cost-effective than PM-guided screening (the ICER could fall below the WTP threshold of 5,000,000 JPY).

Probability Sensitivity Analysis

Figure 3 shows the cost-effectiveness acceptability curves. At a WTP threshold of 5,000,000 JPY, PM-guided screening was the most cost-effective option and the acceptability was above 50%. However, at a WTP threshold of >7,000,000 JPY, PSG-guided screening was superior to PM-guided screening. Importantly, OSA screening was more cost-effective than no screening across all ranges of WTP threshold. Incremental cost-effectiveness scatter plots are shown in **Figure 4**. The probabilities for both OSA screening methods to be cost-effective relative to no screening were both 76.9% (**Figure 4A**,**B**), and PSG-guided screening did not show a clear benefit compared with PM-guided screening (**Figure 4C**).

Scenario Analyses

The main cost-effectiveness results of scenario analyses are summarized in **Table 4**. The scenario analyses revealed that both OSA screening methods were dominant (less costly and more effective) relative to no screening, and PM-guided screening was the most cost-effective strategy in patients with low and high OSA risks. In addition, results of deterministic sensitivity analysis and PSA in both scenarios are shown in **Supplementary Figures 2**–**4**, which yielded the same conclusions to the main analyses.

Discussion

The present study suggests that OSA screening and CPAP therapy before CA is a cost-effective therapeutic strategy in patients with symptomatic AF. For OSA screening, Type 3 PM may be a more cost-effective diagnostic tool than PSG.

Population Health Relevance of the Question

Reflecting the aging population, the number of AF patients has been gradually and steadily increasing in Japan. Inoue et al reported that, in 2050, the number of people with AF was projected to be approximately 1 million (an overall prevalence of >1%).[43] The healthcare costs regarding AF are significant at a national level,[1–3] so the efficient use of resources and cost-effectiveness should be considered.

Importance of OSA Management for AF Treatment

In the past 20 years, CA for AF has become accepted as standard therapy for symptomatic AF, especially paroxysmal AF. However, the recurrence of AF has remained the biggest limitation in this treatment.[4–7] Not only are technological and procedural considerations important for improving the outcome of CA for AF, but so is proper risk management of AF recurrence. Although OSA is one of the main risk factors for the incidence and recurrence of AF, this risk is modifiable because CPAP therapy for OSA is highly effective.[44] Indeed, recent meta-analyses have proven that proper OSA management using CPAP could improve AF outcomes.[10,11] Thus, the latest European Society of Cardiology guideline for AF specified that OSA treatment should be optimized to reduce AF recurrence and improve AF treatment results.[13] In the present study, we evaluated the cost-effectiveness of preprocedural OSA management in patients who elect to undergo CA for symptomatic AF, and revealed that OSA management before CA can be a cost-effective therapeutic strategy due not only to a reduction in the demand for invasive and expensive treatments, but also because of improved results. The findings of this study support the guideline recommendations, even though they have not been widely followed.

Advantage of Type 3 PMs for OSA Screening in Patients With AF

The present study also revealed that Type 3 PM-guided OSA screening can be a more cost-effective diagnostic strategy than PSG-guided screening. Although PSG is the gold standard diagnostic test for OSA, this procedure is complicated, time-consuming, and expensive. According to data from the Ministry of Health, Labour and Welfare of Japan, more than 60,000 patients undergo CA for AF in Japan annually, and the feasibility of performing OSA screening with PSG in all these patients is unrealistic. Type 3 PM has emerged as simple and useful alternative diagnostic tool for OSA, especially in patients at high risk of OSA.[26,45–47] Rosen et al reported results of a multisite randomized trial comparing Type 3 PM-guided screening and treatment with PSG-guided screening for OSA management, reporting that PM-guided OSA management was non-inferior in terms of acceptance, adherence, time to treatment, and functional improvements.[47] Moreover, a recent cost-effectiveness analysis comparing Type 3 PM with PSG for OSA screening demonstrated that at-home testing using PM could be a cost-effective alternative to in-laboratory testing in a population at high risk of OSA.[48] The prevalence of OSA in patients with AF is higher than that of the general population, so patients with AF may be a suitable population for PM-guided OSA management.[28,49] These findings suggest that physicians should consider OSA screening using this simple tool before CA as part of the decision-making process for the treatment of symptomatic AF.

Study Limitations

Several study limitations need to be acknowledged. First, we hypothesized that patients who were free from AF by CPAP therapy would not undergo AF ablation. Although this is the ideal, in the real-world clinical setting patients with OSA receive CPAP therapy and then undergo AF ablation regardless of the recurrence or not of AF. Thus, we performed a supplementary analysis using the modified Markov model (**Supplementary Figure 5**). In this supplementary analysis, all patients would undergo AF ablation regardless of the situation of OSA and CPAP. The results of this supplementary analysis are summarized in **Supplementary Table 2** and **Supplementary Figures 6–8**, and suggest that both OSA screening methods were still cost-effective compared with no screening. Second, although several studies demonstrated that CPAP therapy could improve QOL scores in patients with OSA,[35,50] the degree to which CPAP can improve these scores is unclear. In addition, patients with AF generally lack major symptoms related to OSA (i.e., sleepiness).[51] Thus, to focus on the effect of CPAP on AF treatment, we performed 1 more supplementary analysis using the same Markov model (**Figure 1**), excluding the effect of CPAP on QOL scores. The results of this supplementary analysis are summarized in **Supplementary Table 3** and **Supplementary Figures 9–11**, and showed that OSA management before CA for symptomatic AF was still cost-effective even when excluding the contribution of CPAP on QOL scores. Third, we used the probability of CPAP intolerance (range 17.0–54.0%) based on patients with symptomatic OSA because there are no data for patients with AF. However, the probability of CPAP intolerance in patients with than without AF because of the lack of symptoms related to OSA.[51] Fourth, we assumed the probability of AF recurrence in patients with CPAP and medication therapy based on a single observational study[21] because there are no randomized control studies comparing CA and CPAP therapy for AF treatment. Thus, we performed an additional 1-way sensitivity analysis regarding the relative risk of AF recurrence comparing CPAP and medication therapy with CA (**Supplementary Figure 12**). This additional analysis demonstrated the same conclusions even if the AF recurrence rate on CPAP and medication therapy was very high relative to CA for AF. Fifth, we selected an RDI ≥10 as the cut-off value for PSG in Type 3 PM-guided screening because several studies have demonstrated an association between cardiovascular disease and mild to moderate OSA.[52–54] However, there is no clear cut-off value for OSA screening, especially using portable tests. Our results could have been affected by the screening threshold for OSA. Sixth, our model did not include other cardiac disease affected by OSA and CPAP, such as heart failure and ischemic disease. In addition, the probability of refusing OSA screening was not considered in this study. Seventh, we did not consider the effect of complications from medication therapy, especially rhythm control. Finally, data regarding the prevalence of OSA in Japanese patients with AF are limited, and further studies are needed to better quantify the benefits of OSA screening and treatment in AF management.

Conclusions

Systematic OSA screening and treatment before CA can be a cost-effective therapeutic option for patients with symptomatic AF, with PM-guided screening being the most

cost-effective. Physicians should consider OSA screening using this simple tool before invasive therapy as part of the decision-making process for the treatment of symptomatic AF.

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Disclosures

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IRB Information

This study was approved by the Ethics Committee of Ehime University School of Medicine (Reference no. 2004018).

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Supplementary Files

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