Effects of Gender on the Prevalence of Obstructive Sleep Apnea in Patients with Coronary Artery Disease

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Study Objective: Male predominance has been observed in obstructive sleep apnea (OSA) studies conducted in the community and sleep clinics. Due to the different demographic and patient risk profiles of the studies involved, we investigated the effects of gender on OSA prevalence among patients with coronary artery disease (CAD).

Methods: We prospectively recruited a cohort of CAD patients for an overnight sleep study using a home testing portable diagnostic device. OSA was defined as apnea-hypopnea index (AHI) ≥ 15 .

Results: One hundred sixty-two consecutive patients (male, $n = 81$; female, $n = 81$) were recruited, and most (60%) presented with acute coronary syndrome. The female patients were older (61 ± 10 versus 56 ± 10 years, $p < 0.001$), less likely to be smokers (8.6% versus 34.6%, $p < 0.001$), and more likely to have diabetes mellitus (70.4% versus 46.9%, $p = 0.002$) and chronic renal failure (17.3% versus 4.9%, $p = 0.012$) than the

male patients. The sleep study's success rate was higher in female than male patients (88.9% versus 74.1%, $p = 0.047$). No significant differences were observed between them in the AHI, oxygen desaturation index, baseline SpO_2 , lowest SpO_2 , or total time $SpO_2 < 90\%$. The prevalence of OSA for the female and male patients was 40.3% and 35.0%, respectively ($p = 0.323$).

Conclusion: Prevalence of OSA is high in CAD patients with no evidence of sex predilection. The lack of male predominance could be due to females being older and with more comorbidities.

Keywords: gender difference, obstructive sleep apnea, prevalence, coronary artery disease

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Obstructive sleep apnea (OSA), which is characterized by episodic partial or complete upper airway collapse during sleep, is often perceived to predominantly affect obese males. Studies in the general population have shown OSA prevalence to be two to four times greater in men than women.¹⁻³ This male predominance is more pronounced in studies conducted in sleep clinics,^{3,4} probably as a result of more atypical presentations by women and/or a low index of suspicion of OSA in women by referring physicians.⁵ The biological mechanisms underpinning the gender-related differences in OSA prevalence remain incompletely understood. The explanations proposed to date include the protective effects of female hormones on fat deposition, the chemical drive to breathe, and leptin levels, as well as the greater airway collapsibility seen in men.^{6,7} As a result of the association between OSA and aging,⁸ women at postmenopausal age and men may have a similar prevalence of OSA.

Apart from causing habitual snoring and excessive daytime sleepiness, there is also growing evidence that OSA is a cardiovascular risk factor and prognostic marker.⁹ OSA is an established secondary cause for hypertension.⁹ OSA has also been shown to be highly prevalent in patients presenting with coronary artery disease (CAD), as well as associated with increased coronary plaque burden and long-term adverse cardiovascular events.¹⁰⁻¹³ Recent guidelines from the European Society of Cardiology suggest that OSA screening and treatment in patients

BRIEF SUMMARY

Current Knowledge/Study Rationale: Male predominance has been observed in obstructive sleep apnea studies conducted in the community and sleep clinics. We investigated the effects of gender on obstructive sleep apnea prevalence among patients with coronary artery disease.

Study Impact: Prevalence of obstructive sleep apnea is high in coronary artery disease patients with no evidence of sex predilection. Physicians considering obstructive sleep apnea screening for patients with coronary artery disease should be aware of the absence of male predilection in this patient cohort.

presenting with CAD may result in decreased cardiac events and cardiac death.¹⁴ With recent randomized trials showing that OSA treatment reduces cardiovascular risks,^{15,16} it is conceivable that demand for OSA screening among patients presenting with cardiovascular diseases will increase.

Compared with OSA subjects in the community and sleep clinics, patients hospitalized for symptomatic CAD are usually older and have more comorbid conditions. Yet the effects of gender on OSA prevalence in this subgroup of patients remain to be elucidated. Such data are crucial for establishing an effective screening strategy for CAD patients. In this exploratory study, we investigated the gender effects on systematic in-hospital screening for OSA in a consecutive series of female and male patients hospitalized for CAD.

METHODS

Study Design and Subjects

This was a prospective observational study conducted in a multi-ethnic Asian country. We recruited consecutive patients hospitalized at the National University Heart Centre Singapore for management of symptomatic CAD. The individual management strategies, including pharmacological therapy and percutaneous coronary intervention, were left to the discretion of the attending cardiologists and were in accordance with standard guidelines. After treatment initiation and clinical stabilization, suitable patients were approached before hospital discharge to take part in an overnight sleep study carried out using a portable diagnostic device.

To confirm the diagnosis of CAD, only patients who had undergone coronary angiography and been found to have > 50% stenosis in at least one coronary artery were deemed eligible. The exclusion criteria included moderate to severe pulmonary disease, intubation for mechanical ventilation, use of an intra-aortic balloon pump or other hemodynamic support device, sedation or other muscle relaxant given during hospitalization, perceived high risk of malignant ventricular arrhythmia, cardiogenic shock with systolic blood pressure < 90 mm Hg, clinical heart failure requiring oxygen supplementation, referral for coronary artery bypass surgery, and inability to provide informed consent. The study protocol, which was approved by the local institutional review board (Reference number: DSRB-C: 2012-00051), was explained to all patients in detail, and their informed consent was obtained.

Overnight Sleep Study

Consenting patients were scheduled to take part in an overnight sleep study conducted using a standardized level 3 portable diagnostic device (Embletta Gold, Natus Medical Inc., Canada). Relative to full in-laboratory polysomnography, this device is limited by its inability to examine sleep staging and lack of objective measurement of sleep duration. Nevertheless, it has been validated for use to diagnose OSA against in-lab polysomnography,¹⁷ and possesses sensitivity and specificity ranging from 92% to 97% and 64% to 96%, respectively.¹⁸⁻²⁰ The output recorded with the portable diagnostic device includes nasal airflow (nasal pressure transducer), thoracoabdominal movements (inductive respiratory bands), and arterial oxygen saturation (pulse oximetry). The sleep studies of all patients were scored manually by an independent sleep technologist with registered polysomnographic technologist credentials who was blinded to the patients' clinical characteristics. In line with the study protocol, recordings < 4 h of artifact-free tracings were considered unsuccessful, and unsuccessful sleep studies were not repeated.

The primary measure was the apnea-hypopnea index (AHI), quantified as the total number of apneas and hypopneas per hour of sleep. Apnea was defined as $\geq 90\%$ decrease in airflow from the baseline value for ≥ 10 seconds. Apneas are further classified as obstructive or central based on the presence or absence of respiratory-related chest wall movement. Hypopnea is defined as a 30% to 90% reduction in airflow from the baseline value ≥ 10 sec in conjunction with $\geq 4\%$ oxygen desaturation.

The respiratory event scoring was performed in accordance with the American Academy of Sleep Medicine's 2007 (alternative) guidelines.²¹ The presence of OSA was identified as $AHI \geq 15$, based on the latest clinical guidelines released by the Adult Obstructive Sleep Apnea Task Force of the American Academy of Sleep Medicine.¹¹

Measurements and Data Collection

The demographic and clinical characteristics of the recruited patients were captured from hospital case records. These included age, gender, cardiovascular risk factors (cigarette smoking, hypertension, diabetes mellitus, hyperlipidemia, family history of premature CAD), previous myocardial infarction, previous percutaneous coronary intervention, previous coronary artery bypass graft, previous cerebrovascular accident, chronic renal failure, and principal diagnosis of the index admission. Echocardiograms were carried out to determine the left ventricular ejection fraction before coronary angiography. Patients' height and weight were measured, and their body mass index (BMI) was calculated.

Statistical Analysis

The continuous variables were assessed using an independent-sample *t*-test and summarized using mean and standard deviation if the data were normally distributed, and a Mann-Whitney U test with summary statistics presented using median and interquartile range if the data were skewed. The χ^2 test was used to evaluate categorical variables which were summarized using counts and percentages. All statistical evaluations were made assuming a 2-sided test based on a 5% level of significance using STATA version 11.

RESULTS

Demographic and Clinical Characteristics

Between December 2011 and April 2014, 288 consecutive patients were deemed eligible for the study. They were contacted by a study nurse who inquired about their availability and interest in the study. One hundred twenty-six patients refused to give consent, and 162 consecutive patients (men, $n = 81$; women, $n = 81$) were successfully recruited (**Figure 1**). The patients' demographic and clinical characteristics are presented in **Table 1**. The female patients were older than the male patients (61 ± 10 versus 56 ± 10 years, $p < 0.001$), and most ($n = 70$, 86%) were postmenopausal. Although the female patients were shorter and weighed less than their male counterparts, there was no significant difference between them in BMI. The female patients were less likely to be smokers and more likely to have diabetes mellitus and chronic renal failure.

Most (60%) of the recruited patients presented with acute coronary syndrome, which comprises ST-segment elevation myocardial infarction, non-ST-segment elevation myocardial infarction, and unstable angina. The median left ventricular ejection fraction and prevalence of left ventricular systolic dysfunction determined by 2-dimensional echocardiography was similar between female and male patients (**Table 1**). There were no significant differences between male and female

patients with regard to history of previous myocardial infarction, stroke, percutaneous coronary intervention, and coronary artery bypass surgery (data not shown).

Angiographic and Procedural Characteristics

The angiographic and procedural details of the percutaneous coronary intervention are shown in **Table 2**. All of the recruited patients underwent coronary angiography to evaluate their coronary anatomy after hospitalization. Most were diagnosed with single-vessel disease and de novo lesion, but there were no significant differences between the female and male patients with regard to the culprit vessel, lesion location or nature, or number of diseased vessels (data not shown).

All patients underwent successful percutaneous coronary intervention for CAD, and most received coronary stents during the procedure. More female than male patients received a bioresorbable stent. The diameter and length of the stents used for the female and male patients were similar, and there were no significant differences between the 2 patient groups with regard to baseline and final coronary perfusion, as measured by TIMI flow grade.

Success Rate of Overnight Sleep Study

The overall success rate of the sleep study was 81.5%. Of 81 female patients who participated, the sleep study was successful in 72. The reasons for failure included refusal to permit

device hook-up ($n = 2$) and signal loss ($n = 7$). In a subgroup of premenopausal female patients ($n = 11$), the sleep study was successful in 8. Of 81 male patients who participated, the sleep study was successful in 60, with the reasons for failure the same as those in the female cohort (refusal to permit device hook-up: $n = 3$; signal loss: $n = 18$). Overall, the sleep study success rate was higher in female than male patients (88.9% versus 74.1%, $p = 0.047$). None of the patients developed complications as a result of the sleep study.

Figure 1—Study flow chart.

Table 1—Patient demographics and clinical characteristics.

Characteristics	Overall (n = 162)	Male (n = 81)	Female (n = 81)	p value
Age (years), mean (SD)	58.6 (0.8)	55.9 (10.2)	61.2 (9.5)	< 0.001
Ethnicity				0.624
Chinese	108 (66.7)	53 (65.4)	55 (67.9)	
Malay	37 (22.8)	17 (21.0)	20 (24.7)	
Indian	14 (8.6)	9 (11.1)	5 (6.2)	
Other	3 (1.9)	2 (2.5)	1 (1.2)	
Height (m), mean (SD)	1.61 (0.08)	1.66 (0.06)	1.55 (0.07)	< 0.001
Weight (kg), mean (SD)	67.3 (13.1)	71.5 (10.7)	62.9 (14.0)	< 0.001
Body mass index in kg/m ² , mean (SD)	26.0 (4.4)	25.8 (3.5)	26.2 (5.1)	0.615
Cardiovascular risk factors, n (%)				
Smoking	35 (21.6)	28 (34.6)	7 (8.6)	< 0.001
Hyperlipidemia	141 (87.0)	70 (86.4)	71 (87.7)	0.815
Hypertension	104 (64.2)	47 (58.0)	57 (70.4)	0.101
Diabetes mellitus	95 (58.6)	38 (46.9)	57 (70.4)	0.002
Insulin dependent diabetes mellitus	17 (10.5)	3 (3.7)	14 (17.3)	0.005
Family history of coronary artery disease	28 (17.3)	17 (21.0)	11 (13.6)	0.212
Chronic renal failure	18 (11.1)	4 (4.9)	14 (17.3)	0.012
Clinical presentations, n (%)				0.545
ST-elevation myocardial infarction	36 (22.2)	16 (19.8)	20 (24.7)	
Non-ST-elevation myocardial infarction	49 (30.3)	28 (34.6)	21 (25.9)	
Unstable angina	13 (8.0)	5 (6.2)	8 (9.9)	
Stable angina/Silent ischemia	64 (39.5)	32 (39.5)	32 (39.5)	
Echocardiographic findings				
Median left ventricular ejection fraction (%), IQR	58 (30–70)	55 (30–65)	59 (35–68)	0.481
Left ventricular ejection fraction < 50% (n, %)	30 (30.6)	14 (30.4)	16 (30.8)	0.971

CABG, coronary artery bypass grafting; CVA, cerebrovascular accident; SD, standard deviation; IQR, interquartile range.

Table 2—Angiographic and procedural characteristics.

Characteristics	Overall (n = 162)	Male (n = 81)	Female (n = 81)	p value
Culprit vessels, n (%)				0.412
Left anterior descending artery	99 (61.1)	51 (63.0)	48 (59.3)	
Left circumflex artery	21 (13.0)	13 (16.1)	8 (9.9)	
Right coronary artery	37 (22.8)	16 (19.8)	21 (25.9)	
Left main artery	1 (0.6)	1 (1.2)	0 (0.0)	
Saphenous vein graft	4 (2.5)	1 (1.2)	3 (3.7)	
Number of vessel diseased, n (%)				0.328
1	141 (87.0)	73 (90.1)	68 (84.0)	
2	16 (9.9)	7 (8.6)	9 (11.1)	
3	5 (3.1)	1 (1.2)	4 (4.9)	
Stent/Balloon types, n (%)				0.046
Drug-eluting stent	110 (67.9)	58 (71.6)	52 (64.2)	
Bare metal stent	17 (10.5)	9 (11.1)	8 (9.9)	
Bioengineered stent	2 (1.2)	2 (2.5)	0 (0.0)	
Balloon angioplasty	11 (6.8)	6 (7.4)	5 (6.2)	
Drug-eluting balloon	12 (7.4)	5 (6.2)	7 (8.6)	
Bioresorbable stent	9 (5.6)	0 (0.0)	9 (11.1)	
Thrombectomy	1 (0.6)	1 (1.23)	0 (0.0)	
Stent diameter (mm), mean (SD)	2.87 (0.47)	2.93 (0.42)	2.81 (0.51)	0.135
Stent length (mm), mean (SD)	27.2 (12.5)	27.7 (13.1)	26.8 (12.0)	0.651

Table 3—Sleep study.

Characteristics	Overall (n = 122)	Male (n = 60)	Female (n = 72)	p value
OSA (AHI $\geq$ 15), n (%)	50 (37.9)	21 (35.0)	29 (40.3)	0.323
AHI, median (IQR)	9.9 (0.1–79.2)	8.8 (0.5–44.5)	10.4 (0.8–79.2)	0.210
ODI, median (IQR)	5.7 (0.2–69.0)	5.4 (0.6–45.6)	5.9 (0.3–54.0)	0.859
Baseline SpO ₂ , % (SD)	94.2 (2.2)	94.4 (2.1)	94.1 (2.3)	0.400
Lowest SpO ₂ , % (SD)	83.8 (8.0)	84.5 (7.7)	83.3 (8.4)	0.422
Total time SpO ₂ < 90%, median (IQR)	1.4 (0–145.6)	0.9 (0–61.5)	1.8 (0–117.5)	0.053
Total % Time SpO ₂ < 90%, median (IQR)	0.3 (0–47.7)	0.3 (0–17.9)	0.4 (0–27.4)	0.141

OSA, obstructive sleep apnea; AHI, apnea-hypopnea index; ODI, oxygen desaturation index; IQR, interquartile range; SD, standard deviation.

Findings of Overnight Sleep Study

The overnight sleep study results are reported in **Table 3**. Among the patients who successfully completed it, the median overall AHI was 9.9 (0.1–79.2). No significant differences were observed between the female and male patients in AHI, oxygen desaturation index, baseline SpO₂, lowest SpO₂, or total time SpO₂ < 90%. OSA prevalence in the female and male cohorts was 40.3% and 35.0%, respectively ($p = 0.323$). None of the 8 premenopausal female patients who completed the sleep study were found to have OSA.

Hospital Discharge and Referral to Sleep Clinic

Upon hospital discharge, the level of evidence-based medication prescriptions was high in both patient groups, with no significant difference between them. All participating patients were informed of the sleep study results one month after hospital discharge. Of the 29 female patients with newly diagnosed OSA who were offered the option of further evaluation at a sleep clinic, only 4 (13.8%) accepted. Similarly, of the 21 male patients offered such a referral, just 3 (14.2%) accepted.

DISCUSSION

We prospectively evaluated the effects of gender on systematic screening for OSA in patients hospitalized for symptomatic CAD. An in-hospital overnight sleep study conducted using a level 3 portable diagnostic device was carried out on 162 consenting patients. In this preliminary study, we found significant differences in the demographic and cardiovascular risk factor profiles of the female and male patients. The overall success rate of the sleep study was 82%. In contrast to previous studies conducted in the community and in sleep clinics, the prevalence of OSA and OSA-related parameters was similar among the female and male patients. One month after discharge, only 14.0% of patients with newly diagnosed OSA accepted a referral to a sleep clinic for further evaluation.

The burgeoning interest in OSA screening stems from increased appreciation of its role in the pathogenesis of cardiovascular diseases. Although in-laboratory polysomnography remains the gold standard for diagnosing OSA, there is only limited access to it in much of the world. A portable sleep study

conducted in a hospital setting is an inexpensive and convenient way to circumvent this problem. Such studies have been shown to provide diagnostic and treatment results equivalent to those of in-laboratory sleep studies, and they are currently covered by insurance in the United States when used in the diagnosis of OSA.^{22,23} According to the American Academy of Sleep Medicine, a portable diagnostic device is an acceptable alternative when “in-laboratory polysomnography is not possible by virtue of immobility, safety and critical illness.”²⁴ Patients who present with acute coronary syndrome and/or who have recently undergone percutaneous coronary intervention should fall into this category.

In contrast to previous epidemiological studies conducted in the community and sleep clinics, no male predilection toward OSA was identified in this study. Indeed, we found slightly higher OSA prevalence among women than men. While there is growing evidence that OSA may be a prognostic marker for cardiovascular disease, most of this knowledge rests on cohorts composed predominantly of men. Our findings highlight the importance of further studies on the impacts of OSA in women with cardiovascular disease. We hypothesize that the absence of male predominance in our cohort of cardiac patients is the result of the differing demographic and risk factor profiles of individuals seen in the community and in sleep clinics.

Women experience an abrupt increase in the risk of CAD after menopause because of the concomitant depletion of estrogen. On average, the female patients in our study were five years older than the male patients, and most were postmenopausal. In fact, all 29 female patients with OSA were postmenopausal. This suggests hormonal change associated with menopause is a likely explanation for the lack of sex predilection observed in our study. Aging has been shown to be an important risk factor for OSA owing to the age-related increase in fat deposition in the parapharyngeal area, lengthening of the soft palate, and changes in the body structures surrounding the pharynx.^{25,26} Moreover, in postmenopausal women, the loss of progesterone and estrogen also lead to changes in respiratory control and functional control of the upper airway that predisposes them to OSA.²⁷ A community study conducted in Hong Kong showed that the male predominance in OSA prevalence decreases with age.²⁸ Furthermore, there are ample data supporting the close association between diabetes mellitus, chronic renal failure, and OSA.^{29,30} These two risk factors were significantly more prevalent among the female patients in our study, although more of the male patients were current smokers. The association between smoking and OSA is complex and intriguing. The Sleep Heart Health Study identified an inverse relationship between current smoker status and OSA prevalence,³¹ although the underlying mechanism remains obscure. Finally, postmenopausal women may be more susceptible to the pathophysiological effects of OSA and more likely to develop symptomatic CAD. Irrespective of the reasons, our findings highlight the absence of a sex predilection for OSA in patients hospitalized with symptomatic CAD. It may be that women are generally less prone to developing OSA than men, but by the time they present with symptomatic CAD, the male susceptibility no longer exists.

We excluded patients who were treated with coronary artery bypass surgery, a subgroup reported to have a high prevalence

of OSA.³² Yet, in real-world clinical practice, significantly more patients undergo coronary revascularization with percutaneous coronary intervention than coronary artery bypass surgery. Therefore, the excluded surgical candidates constituted a small proportion of CAD patients, and the OSA prevalence reported in this study should be very close to the actual prevalence among all patients presenting with symptomatic CAD.

Despite the wealth of data in the literature showing an association between OSA and adverse cardiovascular events, and the potential benefits of continuous positive airway pressure in ameliorating the risk of such events, most of the cardiac patients in our study declined enrolment at a sleep clinic. Research has demonstrated that patients' attitudes and health beliefs prior to diagnosis may predict their intention to obtain OSA treatment.³³ The low sleep clinic enrolment rate in this study (14%) reflects the low awareness rate of the effects of OSA in our patient cohort. Recently, ambulatory models of care for OSA by trained nurses and general practitioners have achieved promising results.³⁴ Public education about the benefits of OSA screening and treatment at the community level may represent a more effective way of improving the take-up rate of sleep clinic referrals than reliance on sleep physicians.

Limitations

Our findings must be interpreted in light of the study's limitations. For example, the small sample size precludes a conclusive statement of our results. For the same reason, it was inappropriate to conduct subgroup analysis based on patients' different clinical presentations. A further limitation is that the study was conducted in a multi-ethnic Asian country, and there is evidence to suggest that the mechanism of OSA may differ between Asians and Caucasians.³⁵ OSA in Asians is primarily the result of craniofacial skeletal restriction, whereas in Caucasians it is related to obesity.³⁵ Thus, it remains unknown whether the results of this study can be extrapolated to Caucasians.

CONCLUSION

Among a cohort of patients hospitalized for CAD, the success rate of an overnight sleep study conducted using a level 3 portable diagnostic device was 82%. In contrast to previous studies carried out in the community and sleep clinics, no significant difference was found in the prevalence of OSA between male and female CAD patients. The most likely explanation for this result is the older age and higher prevalence of OSA-linked risk factors among the female patients in this study relative to their male counterparts. Physicians considering OSA screening for patients with CAD should be aware of the absence of male predilection in this patient cohort.

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