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The value of screening questionnaires and scoring scales for obstructive sleep apnoea in patients with atrial fibrillation

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Summary

Background. – Obstructive sleep apnoea (OSA) is an important modifiable risk factor for atrial fibrillation (AF) but is underdiagnosed in this population. Currently, polysomnography is the gold standard for diagnosing OSA, but is expensive and requires overnight examination. Alternatively, home sleep apnoea testing can be used as a diagnostic tool, but also requires a complete data review. Therefore, these OSA diagnostic modalities are not ideal screening methods. Several OSA screening tools exist, but their value in patients with AF remains unclear.

Aim. – To test the performance of existing screening questionnaires/scales for clinically relevant OSA in patients with AF referred for diagnostic polysomnography.

Methods. – This prospective study compared the performance of seven screening tools (Epworth Sleepiness Scale, Berlin Questionnaire, Sleep Apnea Clinical Score, NoSAS, OSA50, STOP-Bang and MOODS) with polysomnography in the detection of clinically relevant OSA in consecutive patients with AF referred to two sleep clinics.

Results. – A total of 100 patients referred for polysomnography and known previous AF were included. Polysomnography indicated at least clinically relevant OSA (i.e. apnoea-hypopnoea index ≥ 15 events/hour) in 69% of cases, and 33% had severe OSA (apnoea-hypopnoea index > 30 events/hour). In screening for clinically relevant OSA, only the SACS and NoSAS scores had fair areas under the curve (0.704 and 0.712, respectively). None of the seven screening tools was performant enough (i.e. had a fair area under the curve > 0.7) in the detection of severe OSA.

Conclusions. – In this AF cohort referred for polysomnography, clinically relevant OSA was prevalent. None of the selected screening tools showed sufficient performance as a good discriminative screening tool for clinically relevant OSA in patients with AF. Given these findings, other screening modalities for OSA should be considered in the workup of patients with AF.

Résumé

Contexte. – L'apnée obstructive du sommeil (AOS) est un important facteur de risque modifiable de la fibrillation auriculaire (FA). Cependant elle reste sous-diagnostiquée dans cette population. Actuellement, le diagnostic de l'AOS est fait par une polysomnographie qui est malheureusement un examen coûteux et laborieux. Alternativement, le test d'apnée du sommeil à domicile pourra être utilisé comme outil de diagnostic, mais nécessite également un examen complet des données. Par

conséquent, ce ne sont pas les méthodes de dépistage idéales. Il existe plusieurs alternatives pour le dépistage de l'AOS, mais leur valeur chez les patients atteints de FA reste incertaine.

Objectif. – Tester la performance des méthodes de dépistage pour l'AOS cliniquement pertinente chez les patients atteints de FA référés pour polysomnographie diagnostique.

Méthodes. – Cette étude prospective a comparé la performance de sept méthodes de dépistage pour détecter l'AOS cliniquement pertinente (l'Epworth Sleepiness Scale, le Berlin Questionnaire, le Sleep Apnea Clinical Score, NoSAS, OSA50, STOP-Bang et MOODS) avec polysomnographie chez des patients consécutifs atteints de FA référés à deux cliniques du sommeil.

Résultats. – Un total de 100 patients avec FA antérieure connue référés pour polysomnographie a été inclus. La polysomnographie indiquait au moins une AOS cliniquement pertinente (un indice d'apnée-hypopnée (IAH) ≥ 15 événements / heure) dans 69 % des cas et 33 % avaient une AOS sévère (IAH > 30 événements / heure). Concernant le dépistage de l'AOS cliniquement pertinente, seuls les questionnaires de dépistage SACS et NoSAS montraient une aire sous la courbe (ASC) acceptable à 0,704 et 0,712 respectivement. Aucun des sept questionnaires de dépistage / systèmes de score n'était suffisamment performant (ASC moyenne > 0,7) pour la détection d'une AOS sévère.

Conclusions. – Dans cette cohorte de FA référée pour polysomnographie, l'AOS cliniquement pertinente était prévalente. Aucun de ces 7 tests de dépistage n'a pu montrer une performance suffisante pour la détection de l'AOS cliniquement pertinente chez les patients atteints de FA. Compte tenu de ces résultats, d'autres modalités de dépistage de l'AOS doivent être envisagées dans 'la mise au point' des patients atteints de FA.

KEYWORDS

Atrial fibrillation;

Sleep apnoea;

Screening

MOTS CLÉS

Fibrillation auriculaire ;

Apnée obstructive du sommeil ;

Dépistage

Abbreviations: AF, atrial fibrillation; AHI, apnoea- hypopnoea index; AUC, area under the curve; BQ, Berlin Questionnaire; CarpOSAF, CArdioResPiratory Polygraphy to screen for Obstructive Sleep Apnoea among patients with Atrial Fibrillation; CPAP, continuous positive airway pressure; ESC, European Society of Cardiology; ESS, Epworth Sleepiness Scale; MOODS, Male, Overweight or Obesity, Diabetes mellitus and history of Stroke; NoSAS, Neck circumference, Overweight/obesity, Snoring, Age and Sex; OSA, obstructive sleep apnoea; SACS, Sleep Apnea Clinical Score; STOP-Bang, Snoring, Tiredness, witnessed (Obstructive) apnoeas, arterial hypertension (Pressure), Body mass index, Age, Neck circumference and Gender.

Background

Atrial fibrillation (AF) is the most prevalent sustained arrhythmia worldwide [1, 2]; its increasing prevalence and associated cardiovascular morbidity and mortality put a high burden on patients and the healthcare system [3]. Various modifiable risk factors (e.g. hypertension, diabetes, obesity, obstructive sleep apnoea [OSA]) contribute to the development and progression of AF [4]. Therefore, it is important to detect and treat these factors to optimize the management of AF and reduce the burden of AF on patients and care givers.

OSA is an under-recognized, underdiagnosed and, hence, undertreated condition in the general AF population. The prevalence of clinically relevant OSA (i.e. at least moderate OSA with an apnoea-hypopnoea index [AHI] ≥ 15 events/hour), for which continuous positive airway pressure (CPAP) is reimbursed in patients with AF, is estimated to be between 42.1% and 56.1% [5, 6]. Untreated OSA increases the risk of AF recurrence after rhythm-restoring procedures, and non-randomized observational studies suggest that OSA treatment with CPAP helps to reduce the risk of recurrence and progression of the arrhythmia [7]. Besides its impact on AF progression in the long run, there is also evidence for short-term impact on AF recurrences: a night of more severe OSA has been shown to be directly related to a higher risk of AF during the following day [8].

Screening for OSA in patients with AF should be considered as a Class IIa recommendation, level of evidence B, according to the 2016 European Society of Cardiology (ESC) guidelines for the management of AF, which were applicable when this study was conducted [9]. Also, the most recent European guidelines (2020) point to the rationale for testing for OSA before initiation of rhythm control therapy in symptomatic patients with AF [4]. However, the ESC authors also state that it remains unclear how and when to test for OSA in the standard work-up of patients with AF [4].

Currently, the gold standard for diagnosing OSA is polysomnography, which requires a rather expensive, in-hospital, supervised, overnight examination, and inherently is not an ideal method to screen for OSA [10]. Unsurprisingly, most sleep clinics have long waiting lists. Clinical tools, such as questionnaires and scales, have been proposed to identify general patients at risk of sleep apnoea based on symptoms, medical history and clinical characteristics. However, these questionnaires have not been properly validated in patients with AF [11].

The aim of this prospective study was to test the performance of existing screening questionnaires and scoring scales for clinically relevant OSA in patients with AF referred for a diagnostic polysomnography.

Methods

This study is part of the CarpOSAF project (evaluation of CArdioResPiratory Polygraphy to screen for Obstructive Sleep Apnoea among patients with Atrial Fibrillation; Belgian registration number: B300201835708); it is a prospective multicentre validation study, in which various tools (questionnaires, scoring scales and three different cardiorespiratory polygraphs) were evaluated as screening options for OSA in patients with AF. Study patients were included at two large Belgian tertiary centres: the Antwerp University Hospital and the Jessa Hospital in Hasselt. The research protocol was approved by the ethics committees of the participating centres, and the study was conducted in compliance with the Declaration of Helsinki. All patients provided written informed consent. The primary aim of this article was to examine the predictive value of the seven screening questionnaires/scoring scales for diagnosing clinically relevant OSA in an AF cohort.

Study population

From May 2018 until November 2020, patients who were planned to undergo a polysomnography and who were known to have AF were recruited for this study. Patients were screened consecutively for study inclusion from the sleep clinic agenda, not at cardiology clinics. The referral pathway of included patients was assessed as part of the study. Inclusion criteria were: (1) planned diagnostic polysomnography for diagnosis of sleep disordered breathing; (2) known AF or atrial flutter, with proven diagnosis on an electrocardiogram; and (3) capability to sign the informed consent. Exclusion criteria consisted of: (1) inability to speak and read Dutch; (2) age < 18 years; (3) physical/cognitive impairment (e.g. severe dementia); and (4) participation in other studies.

Procedure

As polysomnography in Belgium is the only recognised sleep apnoea diagnostic modality, patients admitted to the sleep clinic, and who were known to have a history of AF, were invited to participate in

the CarpOSAF study. In other European countries, home-based type II/III portable monitors can be used as an alternative diagnostic modality, but home-based sleep apnoea diagnosis is not allowed in Belgium currently, and sleep apnoea treatment reimbursement is based on a compulsory hospital-based polysomnography diagnosis [12].

A standard workup at the sleep clinic, including medication review and clinical measurements, such as weight, height and neck and waist circumference, was conducted in all study patients. In addition, completion of the Epworth Sleepiness Scale (ESS) at admission was part of the standard workup. After providing written informed consent, the Berlin Questionnaire (BQ) was completed by the patient in the presence of a study investigator. Demographic variables and AF-specific characteristics (type of AF, AF duration, CHA_2DS_2-VASc [Congestive heart failure, Hypertension, Age ≥ 75 years (Doubled), Diabetes, Stroke/transient ischaemic attack/thromboembolism (Doubled) – Vascular disease, Age 65–74 years and Sex category (Female)], HAS-BLED [Hypertension (uncontrolled, > 160 mmHg systolic), Abnormal renal/liver function, Stroke, Bleeding history or predisposition, Labile international normalized ratio, Elderly (> 65 years) and Drugs/alcohol concomitantly]) were derived from the patients' medical files. Using these demographic and clinical variables in combination with the patients' answers on the BQ, the study investigator had sufficient information to complete five other OSA screening questionnaires or scales.

OSA screening questionnaires and scoring scales

A complete overview of the (common) variables of the seven selected questionnaires/scales is depicted in Table 1.

ESS

The ESS is a short questionnaire, validated in patients with various sleep disorders versus controls, which assesses sleepiness symptoms in eight conditions [13]. A final score (0–24) is calculated, and a score ≥ 11 is considered to represent excessive daytime sleepiness.

BQ

The BQ, validated in a primary care setting, assesses the risk of OSA through three domains (snoring, daytime sleepiness, high blood pressure), and includes sex, height, weight and age [14]. High risk of OSA is defined when at least two domains are categorized as positive.

Sleep Apnea Clinical Score (SACS)

The SACS is a scoring scale that takes into account neck circumference, hypertension, snoring and witnessed apnoeas [15]. This questionnaire was validated in patients referred to the sleep clinic. A score between 0 and 110 is calculated, and is divided into three categories corresponding to different risk levels for OSA (< 8: low; 8–14: borderline; 15–110: high).

NoSAS

NoSAS stands for Neck circumference, Overweight/obesity, Snoring, Age and Sex [16], and is a recently developed screening questionnaire validated in a random cohort (n = 2121) of the Lausanne (Switzerland) population aged 35–74 years who had a polysomnography examination. NoSAS generates a score between 0 and 17; a score ≥ 8 is considered as a high risk for OSA.

OSA50

The OSA50 screening tool is based on four items: waist circumference, age, snoring and witnessed apnoeas [17]. Validation was conducted in a primary care setting, in which a score ≥ 5 (out of a maximum of 10) is related to a high risk of OSA.

STOP-Bang

For the STOP-Bang screening questionnaire, validated in surgical patients, eight items are taken into account: Snoring, Tiredness, witnessed (Obstructive) apnoeas, arterial hypertension (Pressure), Body mass index, Age, Neck circumference and Gender [18]. The calculated score (0–8) can be divided into three risk categories for OSA (0–2: low; 3–4: intermediate; 5–8: high).

MOODS

This recently developed screening tool, specific for patients with AF, uses a point-based system (maximum of 7 points), containing four factors: Male (1 point), Overweight (2 points) or Obesity (3 points), Diabetes mellitus (1 point) and history of Stroke (2 points) [19]. Currently, this scoring scale is still being validated for optimization.

Polysomnography

All subjects underwent a polysomnography examination (Brainlab RT software [Micromed, Kontich, Belgium] at the Antwerp University Hospital; Dream software [Medatec, Brussels, Belgium] at the Jessa Hospital). Data were scored manually by the staff at the sleep clinics, according to the American Academy of Sleep Medicine 2012 criteria [20]. Study patients with an AHI < 15 events/hour were considered to have not clinically relevant OSA, for which CPAP treatment is not indicated/reimbursed in Belgium. Severity of clinically relevant OSA was further classified according to AHI (15–30 = moderate OSA; > 30 = severe OSA) [20].

Statistical analysis

Data were analysed using SPSS, version 27.0 (IBM, Armonk, NY, USA). Variables are described as numbers and percentages or as means ± standard deviations, as appropriate. Normal distribution was assessed using the Shapiro-Wilk test. For continuous variables, differences between two groups were compared using the independent T-test (parametric) or the Mann-Whitney U test (non-parametric). The χ^2 test was used for categorical variables. *P* values < 0.05 were considered statistically significant.

Sensitivity, specificity, positive predictive value and negative predictive value were calculated for the different cut-off values predicting risk of OSA in the seven questionnaires (based on their recommendations) at AHI cut-offs of ≥ 15 and > 30 events/hour. If these results were ≥ 90% and ≥ 80%, these values were considered very good and good, respectively. Also, Cohen's kappa was calculated between the screening questionnaires (for their specific cut-off values) and the polysomnography result, to calculate the agreement between these measurements in the different AHI cohorts. Receiver operating characteristic curves and corresponding areas under the curve (AUCs) were generated for the ESS, SACS, NoSAS, OSA50, STOP-Bang and MOODS scores to assess their

predictive value for OSA in patients with AF. An AUC > 0.90 was considered as an excellent discriminative potential, 0.80–0.90 was good, 0.70–0.80 was fair and 0.60–0.70 was poor. As the BQ has a dichotomous result, a receiver operating characteristic curve for this questionnaire cannot be generated. These graphs were generated for the AHI thresholds of ≥ 15 and > 30 events/hour. These analyses give an indication of the screening value of each questionnaire compared with the gold standard of polysomnography.

As this was part of a validation study, no specific sample size was calculated. The aim was to include 50 consecutive patients with AF (referred for a diagnostic polysomnography) in each centre.

Results

Patient characteristics

A total of 149 sleep clinic patients with a history of AF were evaluated for inclusion in the study. Nineteen patients were excluded, and 30 patients with AF could not participate, mainly because of refusal to participate (40.0%) and cancellation of the polysomnography or no-show (30.0%) (Fig. 1). The study group analysed comprised 100 patients.

Mean age was 64.0 ± 8.7 years, and mean body mass index was 30.6 ± 5.9 kg/m^2 (Table 2). Only 42% of the patients were referred to the sleep clinic by cardiologists; the others were mainly referred by general practitioners (23%), pneumologists (13%) or other specialists, such as ear nose and throat physicians (8%) and neurologists (4%). The average duration with known AF was 5.4 years, significantly shorter for patients referred by cardiologists versus non-cardiologists (3.6 ± 4.1 vs 6.8 ± 6.3 years, respectively; *P* = 0.002). A history of congestive heart failure was present in 21.0% of the AF study cohort. The modified European Heart Rhythm Association AF symptom score was ≥ 2a in 64.0%, and rhythm control was pursued in 55.0%.

A total of 69 patients with AF (69.0%) had an AHI ≥ 15 events/hour confirmed by the polysomnography examination, with 33 (33.0%) having severe OSA. Most patients with AF had OSA (98.0%).

Performance of the different screening questionnaires and scales in predicting OSA severity in patients with AF

Table 3 shows the sensitivity, specificity, positive predictive value, negative predictive value, AUC and Cohen's kappa for the different cut-off points of the seven screening questionnaires or scales, categorized for the two AHI thresholds. For patients with AHI ≥ 15 events/hour, excellent sensitivity values > 90% were reached for the NoSAS and STOP-Bang (intermediate risk) questionnaires. NoSAS, OSA50, STOP-Bang (intermediate risk) and MOODS (score ≥ 2) had a sensitivity > 90% to detect severe OSA (AHI > 30 events/hour). Specificity remained rather low for all questionnaires across all AHI categories, with the exception of MOODS (score ≥ 5). Cohen's kappa coefficient remained < 0.4 for all screening tools across all categories, reflecting rather poor agreement with the gold standard polysomnography.

At the threshold of ≥ 15 events/hour, only the SACS and NoSAS questionnaires had a fair AUC > 0.7 (Fig. 2A). For severe OSA (AHI > 30 events/hour), none of the screening questionnaires had an acceptable AUC (Fig. 2B). A post-hoc analyses, including only patients with AF without heart failure (*n* = 79), slightly improved the performance of most questionnaires/scales for AHI > 30 events/hour (Table A.1).

Discussion

This is the first study evaluating seven different tools to detect clinically relevant OSA in patients with AF, and comparing those with the gold standard polysomnography. We evaluated not only the most commonly used OSA screening questionnaires already embedded in clinical practice (ESS, STOP-Bang, BQ, SACS, OSA50), but also included more recently developed questionnaires, such as the NoSAS and AF-specific MOODS scores. As the therapeutic relationship of central sleep apnoea in patients with AF is currently unclear, and because the majority (98%) of this AF cohort had predominantly OSA, this paper limits its discussion to OSA in patients with AF.

Our results suggest that for screening clinically relevant OSA (i.e. AHI ≥ 15 events/hour) in patients with AF, only the NoSAS or SACS questionnaires had a fair performance. Surprisingly, none of the tested questionnaires could be used to detect severe OSA in patients with AF. Therefore, the usefulness of these OSA screening tools is highly questionable in patients with AF.

The high occurrence and impact of clinically relevant OSA in patients with AF

OSA is common in the general population, but more prevalent in patients with cardiovascular disease [21]. In the AF population referred to arrhythmia clinics, prevalence of moderate-to-severe OSA has been reported to be 42.1–56.1% [5, 6, 22]. In a recent prospective study, including patients with AF from a community cardiology clinic, the prevalence was similar, and was reported to be 49.5% [23]. Our study reports a higher prevalence of 69.0%, although it is difficult to compare populations, as implicit referral patterns may play a role in the composition of the study cohort (e.g. referral by cardiologists or non-cardiologists) and the OSA diagnostic methods used are different (polysomnography as gold standard versus polygraphs).

Detection of OSA in patients with AF is clinically indicated, as OSA influences the progression of this prevalent arrhythmia [7]. Especially in patients with AF undergoing rhythm-restoring procedures, such as catheter ablation, a recent meta-analysis has shown that the presence of OSA increases the risk of recurrent AF, and that CPAP treatment is related to fewer recurrences after catheter ablation [24].

Questionnaires to select patients with AF for referral to a sleep clinic?

Several screening questionnaires and scales for OSA have been validated in different clinical settings (e.g. primary care, preoperative patients), and have proven their utility in specific settings. However, their use and accuracy in patients with AF remains unclear.

The ESS assesses daytime sleepiness, which is an important symptom of OSA, but is only present in 28–35% of patients with an AHI ≥ 15 events/hour [25]. In an AF population undergoing direct current cardioversion, a similar proportion (24%) reported excessive daytime sleepiness, with the sensitivity and specificity of the ESS being 29.1% and 58.3%, respectively, at an AHI cut-off of 15 events/hour [26]. In more recent studies in patients with paroxysmal or persistent AF, the ESS also showed a poor performance (AUC < 0.6) across all AHI categories [6, 27]. These results are similar to our findings across all AHI categories. In general, self-reported daytime sleepiness correlates very poorly with AHI, with the ESS lacking the qualities of a good tool for detecting OSA in patients with AF.

The BQ is one of the most widely cited screening tools [28]. In patients with paroxysmal AF, Traaen et al. reported a sensitivity of 56% and a specificity of 70% for an AHI cut-off ≥ 15 events/h [6]. A second study in patients with paroxysmal AF calculated a sensitivity of 72% and a specificity of 58% (AHI ≥ 15 events/h) [29]. Compared with our results, the sensitivity of the BQ rises with higher AHI category, but specificity remains low. As daytime sleepiness is one of the BQ categories, and is a poor marker for OSA in patients with AF, as mentioned earlier, this factor may have influenced the performance of the BQ.

As described before, the SACS questionnaire has been validated in patients referred to a sleep clinic, similar to our study, in which patients were referred not only by cardiologists (42.0%), but also by general practitioners (23.0%) and pneumologists (13.0%). Although the SACS questionnaire has not yet been validated in an AF population specifically, our analysis showed a fair AUC for the SACS for AHI ≥ 15 events/hour only.

The NoSAS score is currently the most promising screening questionnaire, with better performance than STOP-Bang and the BQ in the general population [16]. Until now, only two studies have reported the value of the NoSAS questionnaire in AF populations compared with ambulatory polygraphs. In paroxysmal patients with AF, May et al. reported high sensitivity (91%), but low specificity (38%) in detecting AHI ≥ 15 events/hour (AUC = 0.74) [29]. In a more general AF population, NoSAS performed with an AUC of 0.68 and 0.69 for classifying moderate and severe OSA, respectively [23]. Our analysis showed similar results for the NoSAS questionnaire, and concluded that it performed best compared with the other questionnaires, although specificity remains very low.

The four-item OSA50 questionnaire has only been tested in a population at high cardiovascular risk (AF not specified), in which the AUC remained < 0.70, as seen in our AF population [30].

Regarding the STOP-Bang questionnaire, more studies are available in patients with AF. In 95 patients with paroxysmal or chronic AF recruited from arrhythmia clinics, the STOP-Bang questionnaire had a similar high sensitivity (100%), but low specificity (19%) for intermediate OSA risk, and a sensitivity of 59.4% and specificity of 61.3% for high OSA risk (both for detecting at least moderate OSA) [31]. In patients with paroxysmal AF, the calculated AUC was 0.68 for AHI thresholds ≥ 15 events/h [6]. Overall, and compared with our results, STOP-Bang did not have a fair performance (AUC > 0.70) for predicting AHI across all categories.

For the MOODS scoring scale, a recently developed OSA screening tool for patients with AF, the AUC for predicting moderate-to-severe OSA remained below the border of 0.70, whereas the first validation report showed an AUC of 0.73 for an AHI ≥ 15 events/hour [19]. The initial MOODS score is currently being further optimized.

The strength of our study is the comparison of all questionnaires with polysomnography as the gold standard for the diagnosis of OSA. As mentioned above, several studies have compared the screening questionnaires with polygraphs, which also have some diagnostic limitations (e.g. failure in execution, fewer detections of hypopnoeas). Moreover, we included all types of patients with AF (first diagnosed as well as permanent AF) who were referred by different medical specialties, thus representing a more overall AF patient population.

Alternative strategies for detecting OSA in patients with AF

When this study was conducted, the ESC 2016 AF guidelines were applicable, which recommended interrogation for clinical signs of OSA in patients with AF with risk factors [9]. As our findings show, these variables are of limited value, even when using the newest OSA screening tools, although a NoSAS score < 8 or a MOODS score < 2 can aid the decision not to refer an AF patient to a sleep clinic, as the negative predictive value for these two questionnaires was > 90% (for AHI > 30 events/hour). In the recent 2020 AF guidelines, this recommendation to assess clinical signs of OSA is no longer included, but the knowledge gap regarding how and when to test for OSA is emphasized [4]. Our study results provide more evidence about the 'how' question, in the sense that they show that validated screening questionnaires are not reliable enough in patients with AF. Therefore, other OSA detection modalities need to be considered, among which the polygraph (type III portable monitor) may be a promising tool. The advantages of this tool are the execution at the patient's home, the low cost and, for some polygraphs, the availability of an automated algorithm to detect sleep disordered breathing patterns. However, polygraphs may have a higher failure rate than polysomnography, and sometimes need a cumbersome manual review of the data to be reliable [32]. Other screening alternatives, such as overnight oximetry or peripheral arterial tonometry, using fewer channels or a single channel (type IV portable monitor), have been validated, and are also promising detection tools in patients with AF [33, 34].

Besides the need for a reliable OSA screening tool in patients with AF, more prospective studies are needed concerning the impact of OSA treatment on outcomes in AF (e.g. stroke, symptom burden). Also, the AF populations benefiting most from this approach have to be identified (e.g. permanent versus non-permanent AF, symptomatic versus non-symptomatic, depending on the risk profile of the patients with AF, etc.). In addition, evidence is lacking concerning the ideal AHI threshold at which OSA treatment is most effective.

Study limitations

The included patients with AF who were referred for a diagnostic polysomnography may not be representative of a general AF population that is likely to be screened in daily clinical practice, i.e. patients with non-permanent AF in whom rhythm control is pursued (seen at the cardiology department) or even high-risk asymptomatic patients with AF seen in GP practices.

As reflected in the patients' characteristics, 74% of patients with AF had a body mass index > 27 kg/m^2, which could lead to an overestimation of the prevalence of clinically relevant OSA in patients with AF compared with the general AF population. Nevertheless, previous work by our group has shown that 53.4% of the AF population in the same recruiting centres as this study had a body mass index > 27 kg/m^2 [35]. Moreover, as mentioned earlier, the prevalence of moderate-to-severe OSA among all patients with AF included at general cardiology or rhythm clinics, as reported in other studies, was similarly very high [5, 6, 22, 23].

Lastly, the performance of the selected screening tools could be influenced by the inclusion of patients with AF with a history of heart failure, who are known to have fewer subjective OSA symptoms, such as sleepiness [36].

Conclusions

The present study suggests that existing (validated) screening questionnaires and scoring scales, such as ESS, BQ, SACS, NoSAS, OSA50, STOP-Bang and MOODS, probably do not demonstrate sufficient performance when screening for clinically relevant OSA in patients with AF. Given these findings, other screening strategies for OSA should be considered or developed in the (standard) workup of patients with AF.

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Figure legends

Figure 1. Enrolment process. AF: atrial fibrillation; PSG: polysomnography.

Figure 2. Receiver operating characteristic curves predicting obstructive sleep apnoea (OSA) severity in patients with atrial fibrillation. AHI: apnoea-hypopnoea index; ESS: Epworth Sleepiness Scale; MOODS: Male, Overweight or Obesity, Diabetes mellitus and history of Stroke; NoSAS: Neck circumference, Overweight/obesity, Snoring, Age and Sex; SACS: Sleep Apnea Clinical Score; STOP-Bang; Snoring, Ti redness, witnessed (Obstructive) apnoeas, arterial hypertension (Pressure), Body mass index, Age, Neck circumference and Gender.

[a] Area under the curve > 0.70.

Table 1 Content of the selected screening questionnaires and scales.

	ESS	BQ	SACS	NoSAS	OSA50	STOP-Bang	MOODS
Subjective variables							
Sleepiness	X[a]	X				X	
Snoring		X	X	X	X	X	
Witnessed apnoeas		X	X		X	X	
Dozed off while driving		X					
Objective variables							
Age		X		X	X	X	
Sex		X		X		X	X
Body mass index		X		X		X	X
Waist circumference					X		
Neck circumference			X	X		X	
Diabetes mellitus							X
Hypertension		X	X			X	
History of stroke							X

BQ: Berlin Questionnaire; ESS: Epworth Sleepiness Scale; MOODS: Male, Overweight or Obesity, Diabetes mellitus and history of Stroke; NoSAS: Neck circumference, Overweight/obesity, Snoring, Age and Sex; OSA: obstructive sleep apnoea; SACS: Sleep Apnea Clinical Score; STOP-Bang; Snoring,

Tiredness, witnessed (Obstructive) apnoeas, arterial hypertension (Pressure), Body mass index, Age, Neck circumference and Gender.

[a] Assesses sleepiness in eight different conditions.

Table 2 Baseline characteristics of the study population.

	Total study population (n = 100)	Antwerp University Hospital (n = 49)	Jessa Hospital (n = 51)	P^a
Age (years)	64.0 ± 8.7	63.8 ± 10.1	64.2 ± 7.2	0.83
Male sex	73 (73.0)	42 (85.7)	31 (60.8)	0.005
Body mass index (kg/m^2)	30.6 ± 5.9	29.5 ± 5.0	31.6 ± 6.6	0.09
Waist circumference (cm)	108.7 ± 14.2	107.9 ± 14.0	109.5 ± 14.4	0.75
Neck circumference (cm)	41.3 ± 4.0	41.5 ± 3.4	41.2 ± 4.4	0.72
Type of AF				0.21
First diagnosed	14 (14.0)	6 (12.2)	8 (15.7)	
Paroxysmal AF	53 (53.0)	22 (44.9)	31 (60.8)	
Persistent AF	20 (20.0)	12 (24.5)	8 (15.7)	
Permanent AF	13 (13.0)	9 (18.4)	4 (7.8)	
Time since AF diagnosis (years)	5.4 ± 5.6	5.4 ± 5.8	5.4 ± 5.4	0.90
CHA_2DS_2-VASc score	2.4 ± 1.7	2.5 ± 1.9	2.4 ± 1.5	0.83
HAS-BLED score	1.2 ± 0.9	1.3 ± 0.9	1.2 ± 0.9	0.42
mEHRA ≥ 2a	64 (64.0)	27 (55.1)	37 (72.5)	0.07
Referred by cardiologist	42 (42.0)	26 (53.1)	16 (33.3)	0.05
Anticoagulation therapy				0.80
NOAC	58 (58.0)	29 (59.2)	29 (56.9)	
VKA	6 (6.0)	3 (6.1)	3 (5.9)	
None	36 (36.0)	17 (34.7)	19 (37.3)	
Rhythm control	55 (55.0)	35 (71.4)	20 (39.2)	0.001
Congestive heart failure	21 (21.0)	11 (21.6)	10 (20.4)	0.89
SA diagnosis				0.15
Predominant OSA	98 (98.0)	47 (95.9)	51 (100.0)	
Predominant CSA	2 (2.0)	2 (4.1)	0 (0.0)	

SA severity				0.97
No or mild SA (AHI < 15 events/hour)	31 (31.0)	16 (32.7)	15 (29.4)	
Moderate SA (AHI 15–30 events/hour)	36 (36.0)	18 (36.7)	18 (35.3)	
Severe SA (AHI > 30 events/hour)	33 (33.0)	15 (30.6)	18 (35.3)	

Data are expressed as mean ± standard deviation or number (%). AF: atrial fibrillation; AHI: apnoea-hypopnoea index; CHA_2DS_2-VASc: Congestive heart failure, Hypertension, Age ≥ 75 years (Doubled), Diabetes, Stroke/transient ischaemic attack/thromboembolism (Doubled) – Vascular disease, Age 65–74 years and Sex category (Female); CSA: central sleep apnoea; HAS-BLED: Hypertension (uncontrolled, > 160 mmHg systolic), Abnormal renal/liver function, Stroke, Bleeding history or predisposition, Labile international normalized ratio, Elderly (> 65 years) and Drugs/alcohol concomitantly; mEHRA: modified European Heart Rhythm Association AF symptom score; NOAC: non-vitamin K antagonist oral anticoagulant; OSA: obstructive sleep apnoea; SA: sleep apnoea; VKA: vitamin K antagonist.,

[a] Between centres.

Table 3 Performance of the different screening questionnaires and scoring scales in predicting obstructive sleep apnoea severity in patients with atrial fibrillation (*n* = 100).

Questionnaires/scales	Sensitivity	Specificity	PPV	NPV	AUC	κ
AHI ≥ 15 events/hour						
ESS (≥ 11)	30.4 (20.2–42.8)	74.2 (55.1–87.5)	72.4 (52.5–86.6)	32.4 (22.0–44.7)	0.532 (0.411–0.654)	0.034
BQ (positive)	76.8 (64.8–85.8)	48.4 (30.6–66.6)	76.8 (64.8–85.8)	48.4 (30.6–66.6)	-	0.252[d]
SACS					0.704 (0.592–0.817)[c]	
Borderline risk	79.7 (68.0–88.1)	54.8 (36.3–72.2)	79.7 (68.0–88.1)	54.8 (36.3–72.2)		0.345[c,d]
High risk	50.7 (38.5–62.9)	80.6 (61.9–91.9)[b]	85.4 (70.1–93.9)[b]	42.4 (29.8–55.9)		0.251[d]
NoSAS (≥ 8)	92.8 (83.2–97.3)[a]	22.6 (10.3–41.5)	72.7 (62.0–81.4)	58.3 (28.6–83.5)	0.712 (0.601–0.822)[c]	0.184[d]
OSA50 (≥ 5)	89.9 (79.6–95.5)[b]	12.9 (4.2–30.8)	69.7 (58.9–78.7)	36.4 (12.4–68.4)	0.686 (0.576–0.795)	0.034
STOP-Bang					0.673 (0.553–0.794)	
Intermediate risk	98.6 (91.1–99.9)[a]	16.1 (6.1–34.4)	72.3 (62.0–80.8)	83.3 (36.5–99.1)[b]		0.189[d]
High risk	59.4 (46.9–70.9)	61.3 (42.3–77.6)	77.4 (63.5–87.3)	40.4 (26.7–55.7)		0.181
MOODS					0.655 (0.530–0.779)	
Score ≥ 2	89.9 (79.6–95.5)[b]	25.8 (102.5–44.9)	72.9 (62.0–81.7)	53.3 (27.4–77.7)		0.183[d]
Score ≥ 5	13.0 (6.5–23.8)	87.1 (69.2–95.8)[b]	69.2 (38.9–89.6)	31.0 (21.8–42.0)		0.001
AHI > 30 events/hour						

ESS (≥ 11)	33.3 (18.6–51.9)	73.1 (60.7–82.9)	37.9 (21.3–57.6)	69.0 (56.8–79.2)	0.578 (0.456–0.699)	0.067
BQ (positive)	81.8 (63.9–92.4)[b]	37.3 (26.1–50.0)	39.1 (27.8–51.6)	80.6 (61.9–91.9)[b]	-	0.150
SACS					0.666 (0.553–0.779)	
Borderline risk	87.9 (70.9–96.0)[b]	40.3 (28.7–53.0)	42.0 (30.4–54.5)	87.1 (69.2–95.8)[b]		0.221[d]
High risk	54.5 (36.6–71.5)	65.7 (53.0–76.6)	43.9 (28.8–60.1)	74.6 (61.3–84.6)		0.190
NoSAS (≥ 8)	97.0 (82.5–99.8)[a]	16.4 (8.9–27.9)	36.4 (26.6–47.4)	91.7 (59.8–99.6)[a]	0.671 (0.563–0.779)	0.094
OSA50 (≥ 5)	93.9 (78.4–98.9)[a]	13.4 (6.7–24.5)	34.8 (25.2–45.7)	81.8 (47.8–96.8)[b]	0.654 (0.538–0.771)	0.052
STOP-Bang					0.668 (0.556–0.780)	
Intermediate risk	97.0 (82.5–99.8)[a]	7.5 (2.8–17.3)	34.0 (24.8–44.6)	83.3 (36.5–99.1)[b]		0.030
High risk	72.7 (54.2–86.0)	56.7 (44.1–68.6)	45.3 (31.8–59.4)	80.9 (66.3–90.4)[b]		0.255[d]
MOODS					0.649 (0.540–0.758)	
Score ≥ 2	97.0 (82.5–99.8)[a]	20.9 (12.3–32.9)	37.6 (27.6–48.9)	93.3 (66.0–99.7)[a]		0.128[d]
Score ≥ 5	18.2 (7.6–36.0)	89.6 (79.1–95.3)[b]	46.2 (20.4–73.9)	69.0 (58.0–78.2)[b]		0.091

Data are expressed as % (95% confidence interval), unless otherwise indicated. AHI: apnoea- hypopnoea index; AUC: area under the curve; BQ: Berlin Questionnaire; ESS: Epworth Sleepiness Scale; κ= Cohen's kappa; MOODS: Male, Overweight or Obesity, Diabetes mellitus and history of Stroke; NoSAS: Neck circumference, Overweight/obesity, Snoring, Age and Sex; NPV: negative predictive value; OSA: obstructive sleep apnoea; PPV: positive predictive value; SACS: Sleep Apnea Clinical Score; STOP-Bang; Snoring, Tiredness, witnessed (Obstructive) apnoeas, arterial hypertension (Pressure), Body mass index, Age, Neck circumference and Gender.

[a] Very good value.

[b] Good value.

[c] Fair value.

[d] Corresponds with $P < 0.05$.

Figure 1

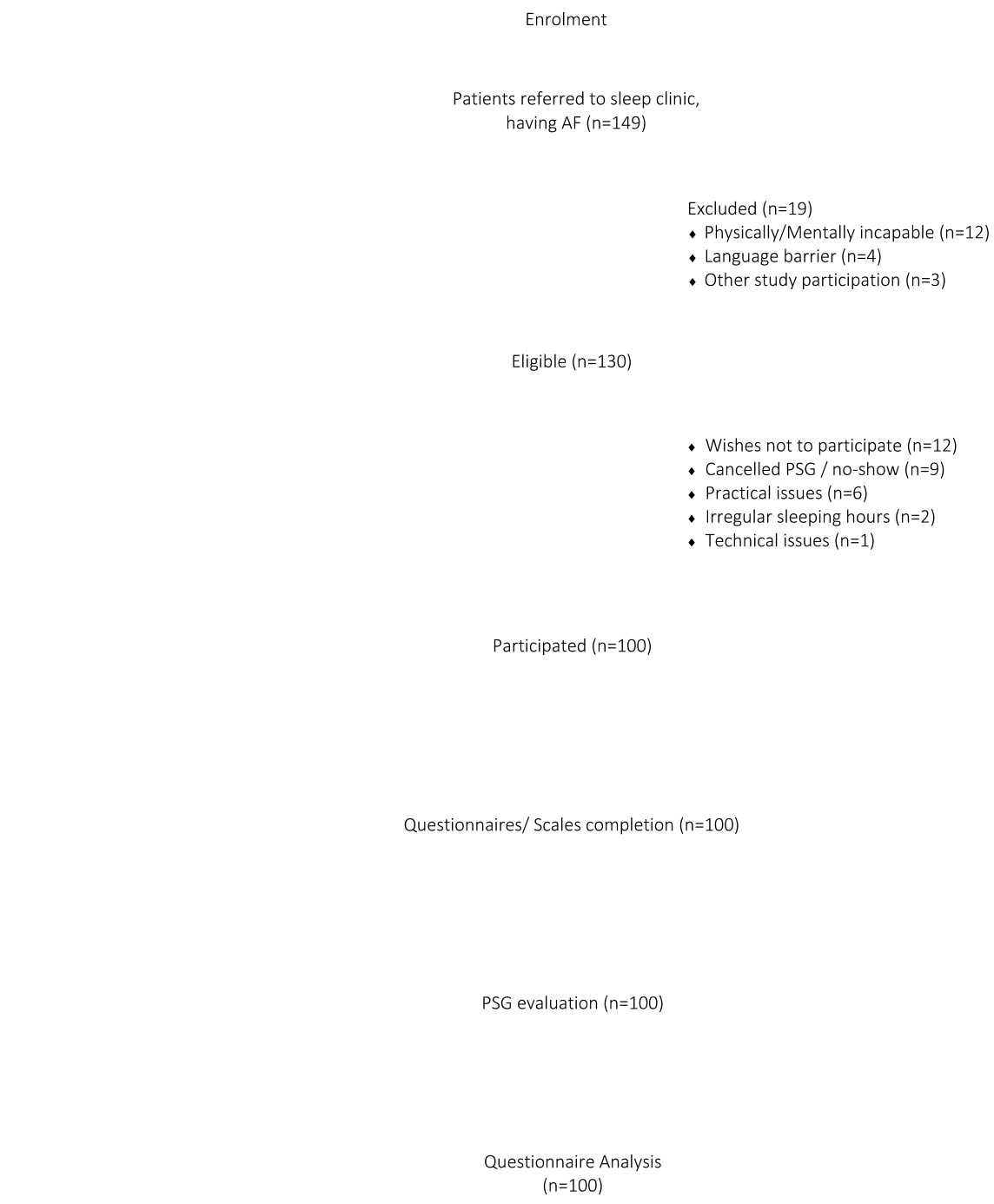
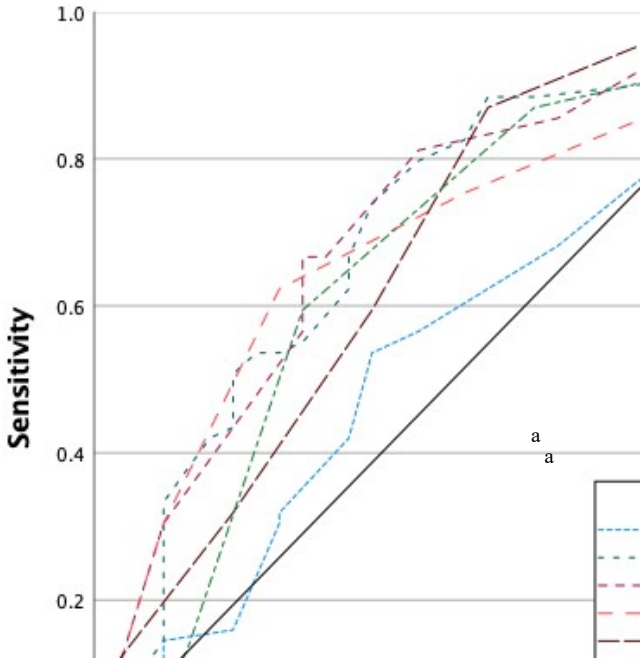

Enrolment
Patients referred to sleep clinic, having AF (n=149)
Excluded (n=19)
Physically/Mentally incapable (n=12)
Language barrier (n=4)
Other study participation (n=3)
Eligible (n=130)
Wishes not to participate (n=12)
Cancelled PSG / no-show (n=9)
Practical issues (n=6)
Irregular sleeping hours (n=2)
Technical issues (n=1)
Participated (n=100)
Questionnaires/ Scales completion (n=100)
PSG evaluation (n=100)
Questionnaire Analysis (n=100)

Figure 2

A. Moderate OSA (AHI ≥ 15)



B. Severe OSA (AHI > 30)