

Relationship between Charlson Comorbidity Index and Obstructive Sleep Apnea severity indicators in a Tunisian cohort

Relation entre l'indice de comorbidité de Charlson et les indicateurs de gravité du syndrome d'apnées hypopnées obstructives du sommeil dans une cohorte tunisienne

Lenda Ben Hmida, Ines Moussa, Nour Lahbib Jallouli, Hana Mrassi, Imen Sahnoun, Leila Douik El Gharbi

University Tunis El Manar, Faculty of medicine of Tunis, 1007, Abderahmen Mami Hospital, Pneumology Department D, 2080, Ariana, Tunisia.

ABSTRACT

Introduction: Obstructive sleep apnea (OSA) is a recognized cardiovascular risk factor, associated with increased morbidity and mortality. Charlson comorbidity index (CCI) is widely used to measure comorbidities in chronic conditions.

Objective: This study aimed to evaluate the CCI as a potential screening tool for severe OSA by assessing its association with OSA severity predictors.

Methods: A retrospective study was conducted at a pneumology department, including OSA patients. The CCI was assessed and its median CCI calculated. Patients were divided to two groups: Group1 including patients with CCI greater than or equal to the median, and group2 below the median.

Results: Median CCI was 3 ± 1.6 . Statistical analysis showed a significant association between a CCI greater than or equal to 3 and age (63 vs 47 years; $p < 0.001$), Stop Bang score (5 vs 4; $p = 0.003$), diastolic blood pressure (80 vs 70 mmHg; $p = 0.023$), glycemia (7 vs 5 mmol/l; $p = 0.0001$), arterial oxygen pressure (82 vs 86 mmHg; $p = 0.009$), desaturation index (32 vs 28/h; $p = 0.022$), minimal nocturnal pulse oxygen saturation (76 vs 78%; $p = 0.005$), and nocturnal pulse oxygen saturation below 90% (17 vs 13%; $p = 0.02$). No significant association was noted between the CCI and Epworth score, Pichot score, body mass index, apnea hypopnea index, mean duration of hypopnea or apnea, and mean nocturnal oxygen saturation. The CCI demonstrated sensitivity of 66% and specificity of 49% at a cutoff of 2.5 (AUC = 0.6, $p < 0.001$).

Conclusion: The CCI showed a significant but modest ability to identify severe OSA, with variable associations across OSA severity predictors.

Keywords: Burden of disease, Comorbidities, Health status, Mortality, Phenotype, Sleep apnea syndrome

RÉSUMÉ

Introduction: Le syndrome d'apnées hypopnées obstructives du sommeil (SAHOS) est un facteur de risque cardiovasculaire. L'indice de comorbidité de Charlson (ICC) est largement utilisé pour mesurer la valeur pronostique des comorbidités dans diverses maladies chroniques.

Objectif: L'objectif de l'étude était d'évaluer l'ICC comme outil potentiel de dépistage du SAHOS sévère en analysant son association avec les facteurs prédictifs de sévérité du SAHOS.

Méthodes: Etude rétrospective était menée dans un service de pneumologie colligeant des patients suivis pour SAHOS. L'ICC était mesurée et sa médiane calculée. Les patients étaient répartis en deux groupes, ICC supérieure ou égale à la médiane et inférieure à la médiane.

Résultats: L'ICC médian était de $3 \pm 1,6$. L'analyse statistique a montré une association significative entre ICC ≥ 3 et âge (63 vs 47 ans; $p < 0.001$), score StopBang (5 vs 4; $p = 0.003$), pression artérielle diastolique (80 vs 70 mmHg; $p = 0.023$), glycémie (7 vs 5 mmol/l; $p = 0.0001$), pression artérielle en oxygène (82 vs 86 mmHg; $p = 0.009$), index de désaturation (32 vs 28/h; $p = 0.022$), saturation minimale nocturne en oxygène (76 vs 78%; $p = 0.005$) et saturation nocturne en oxygène $< 90\%$ (17 vs 13%; $p = 0.02$). Aucune association significative n'était notée entre l'ICC et le score d'Epworth, le score de Pichot, l'indice de masse corporelle, l'index d'apnée hypopnée, la durée moyenne d'hypopnée ou d'apnée et la saturation nocturne moyenne en oxygène. L'ICC a montré une sensibilité de 66 % et une spécificité de 49 % pour une valeur seuil de 2,5 (AUC = 0,6, $p < 0,001$).

Conclusion: L'ICC a montré une capacité significative mais modeste à identifier les formes sévères du SAHOS, avec des associations variables selon les différents prédicteurs de sévérité.

Mots clés : Comorbidités, État de santé, Fardeau de la maladie, Mortalité, Phénotype, Syndrome d'apnée du sommeil

Correspondance

Lenda Ben Hmida

University Tunis El Manar, Faculty of medicine of Tunis, 1007, Abderahmen Mami Hospital, Pneumology Department D, 2080, Ariana, Tunisia.

Email: benhmidalenda@gmail.com

INTRODUCTION

Obstructive sleep apnea (OSA) is a common breathing disorder affecting 2% to 4% of the general adult population (1). OSA is characterized by repetitive episodes of complete or partial pharyngeal collapse during sleep, known as apnea or hypopnea (2). The pharyngeal collapse mechanisms are multiple and multifactorial (2). Topping the list, the anatomical reductions of the upper airway caliber resulting from obesity, or maxillofacial or pharyngeal soft tissue abnormalities (2). Followed by the decrease in pharyngeal dilator activity, pharyngeal neuropathy, impairing protection of upper airway reflexes, or rostral fluid shift from the legs to the neck during sleep (2). These events disrupt gas exchange, trigger intermittent hypoxemia reoxygenation leading to fragmented sleep, high production of oxidative stress and vasoactive mediators, sympathetic excitation, systemic inflammation, endothelium damage, and metabolic dysfunction (3). Therefore, OSA is a prevalent disorder in patients with cardiovascular diseases and known to increase the risk of developing atherosclerosis, hypertension, poor blood pressure control, stroke, myocardial infarction, heart failure, cardiac arrhythmias, sudden cardiac death, and mortality from all causes (4). For specific conditions, various physio pathological mechanisms may be unequally implicated (5). For nocturnal hypertension, sympathetic excitation is thought to be the primary trigger, whereas for coronary artery disease inflammation and oxidative stress seems to be the main driver (5). OSA is also linked to insulin resistance and metabolic syndrome, with the risk being ninefold higher in obese individuals with OSA, independently of obesity, which it appears to have at least an additive effect (6).

Besides cardiovascular and metabolic diseases, OSA is increasingly proved to be associated with a broad spectrum of chronic comorbidities such as renal, pulmonary, and neuropsychiatric conditions (5). These comorbidities can influence the progression, prognosis, and treatment outcomes of OSA (7). Thus, early recognizing and effectively addressing comorbid conditions lead to improve overall outcomes in OSA management and to alleviate the disease burden (7).

Based on their baseline health status and medical history, patients with the same disease can be managed differently (8). In order to assess objectively the impact of these comorbidities on OSA potential morbi-mortality risk, the Charlson Comorbidity Index (CCI) was suggested (8).

As a tool to study the contribution of comorbidities on mortality, particularly in the context of life-threatening conditions, the CCI proved to be useful (9). In fact, the CCI is known as a reliable, sensitive, well-validated, and widely used tool for assessing prognostic comorbidities in various chronic conditions (8).

Given that severe OSA is frequently associated with multiple comorbidities that influence disease severity and outcomes, and that the CCI reliably reflects comorbidity burden and predicts prognosis in chronic conditions, it may also serve as a practical tool to identify patients at risk of severe OSA.

Building on this rationale, the aim of the study was to

evaluate the CCI as a potential screening tool for severe OSA by assessing its association with OSA severity predictors.

METHODS

Study design and sample

This study was retrospective, single-center, and observational, conducted at the Sleep Center of a Pneumology Department in Tunisia. Data were gathered from the medical records of patients diagnosed with OSA through ventilatory polygraphy or polysomnography, performed either in the hospital or at home, between 2014 and 2023.

Out of patient records reviewed, who underwent ventilatory polygraphy or polysomnography, we selected patients diagnosed with OSA. We included patients aged 18 and older, newly diagnosed with OSA in our department, following the American Academy of Sleep Medicine (AASM) scoring standards (10). OSA was defined by an apnea-hypopnea index (AHI) of five or more events per hour of sleep (10). We excluded patients under 18, those with obesity hypoventilation syndrome, other non-respiratory sleep disorders (e.g., narcolepsy, restless legs syndrome, hypersomnia), neurological or muscular diseases (e.g., myopathy, encephalopathy), central sleep apnea, or those taking neuroleptic medications. Patients with incomplete data records were also excluded from the study.

This study was conducted following ethical guidelines. All data collected are confidential and anonymous. The procedures were carried out in accordance with applicable laws and institutional protocols and received approval from the local hospital ethics committee.

Data collection and applied definitions

Data were retrospectively extracted by the medical staff in 2024, from medical records of patients seen for the nine years prior to study enrollment, between 2014 and 2023. For each patient, the recorded clinical data included demographic details (age, gender, etc.), lifestyle habits (such as smoking and stimulant use), medical history, nocturnal and daytime symptoms, as well as weight, height, and body mass index (BMI) (11). The STOP-Bang questionnaire, a screening tool for OSA, was used to assess eight yes/no items related to clinical features of the condition, including snoring, fatigue, observed apneas, high blood pressure, age, neck circumference, and male gender, with a total score ranging from 0 to 8 (12). A STOP-Bang score ≥ 3 is used to detect moderate to severe OSA (12). For diurnal symptoms, daytime sleepiness topped the list, and was assessed by the Epworth sleepiness scale (ESS) (13), filled out by the medical staff during the first consultation. This scale includes eight everyday scenarios in which patients assess their tendency to doze off or fall asleep. For each situation, they assign a score from 0 (never dozing off) to 3 (high likelihood of falling asleep) (13). The total score, which ranges from 0 to 24, is obtained by summing the ratings, with a score above

Statistical Analysis

10 is considered abnormal (13). Severe excessive daytime sleepiness was identified by an ESS score greater than 16 (13). Regarding tiredness, the Pichot's Fatigue scale was used, a containing 8 questions, scored progressively from 0 (not at all) to 4 (extremely) (14). The summed score ranged from 0 to 32 and a total score above 22 revealed excessive fatigue (14). Other clinical features were noted such as the systolic and diastolic blood pressure. The recorded data included biological information (glycemia, arterial blood gas, etc). The polygraphic data obtained from the final ventilatory polygraphy or polysomnography report included the AHI, oxygen desaturation index (ODI), mean and minimum pulse oxygen saturation (SpO2) during sleep, mean apnea and hypopnea duration, as well as the total recording time with SpO2 levels below 90%. Following the AASM recommendations, OSA severity was categorized according to the AHI: mild OSA was defined by an AHI between 5 and 15 per hour, moderate OSA by an AHI between 15 and 30 per hour, and severe OSA by an AHI of 30 or more per hour (10).

The severity of OSA was primarily assessed based on the frequency of abnormal respiratory events and the degree of daytime sleepiness, after ruling out other potential causes of sleepiness (10). Along with the AHI and ESS, additional clinical and polygraphic parameters were evaluated as potential predictors of OSA severity. These included age, Stop Bang score, BMI, Pichot's fatigue scale, blood pressure, glycemia, ODI, mean and minimum SpO2 during sleep, total recording time with SpO2 below 90%, and mean apnea hypopnea duration (12,15–20).

The CCI was calculated by the study investigator based on the data obtained from the patients' charts, which provided information on comorbidities and their severity. A weighted index created by Charlson et al. (21), the CCI was developed and prospectively validated in longitudinal studies with a cohort of 559 patients. This 19-item index with its age-adjusted score (figure 1) classifies various comorbid conditions according to their severity and ability to predict mortality risk, with a cumulative effect (21,22). Each condition is assigned a severity score ranging from one to six, and these scores are summed to produce a final CCI, which is a continuous variable ranging from 0 to 37 (23).

Score	Comorbid Condition
1	Myocardial infarction Congestive heart failure Cerebral vascular disease Peripheral vascular disease Dementia Chronic obstructive pulmonary disease Connective tissue disease Peptic ulcer disease Mild liver disease
2	Diabetes Hemiplegia Moderate/severe renal disease Diabetes with end-organ damage Any solid tumor Leukemia Lymphoma
3	Moderate/severe liver disease
6	Metastatic solid tumor AIDS
Age (y)	
41–50	1 point
51–60	2 points
61–70	3 points
≥71	4 points

Figure 1. The Charlson Comorbidity Index: 19 Items and Age-Adjusted Score

Descriptive analysis of variables was expressed as median $\pm$ standard deviation, mean or percentage (%). The chi-square test was applied to compare percentages between independent groups, and if it was not valid, the two-tailed Fisher test was used instead. For comparing means between two independent samples, the Student's T-test was employed.

The median CCI was calculated. Patients were divided to two groups: Group 1 (G1) including patients with CCI greater than or equal to the median. Group 2 (G2) including patients with CCI below the median. Cross-tabulations were performed to analyze the association between CCI and OSA severity predictors, with statistical significance tested using the chi-square test (or the two-tailed Fisher test).

To evaluate the ability of the CCI to screen for severe OSA, receiver operating characteristic (ROC) curve analysis was performed. The area under the curve (AUC) was calculated to assess the diagnostic performance of CCI. The AUC provides a summary measure of the ROC curve's performance: higher AUC values indicate better predictive performance. An AUC of 0.5 indicates a total absence of discriminating ability in this context, thus the model is null and performs no better than random chance.

For all statistical tests, the significance threshold was set at 0.05 (5%), thus a p-value <0.05 was considered a statistically significant correlation different from zero.

Data were entered and analyzed using SPSS software version 26.0.

RESULTS

From 3965 revised records of patients having had a ventilatory polygraphy or polysomnography, 1993 were diagnosed with OSA, from whom 825 patients were included in the final analysis. The median CCI was 3 ± 1.6 . Patients were distributed to two groups, 485 patients with CCI ≥ 3 were included in G1, and 340 patients with CCI < 3 were included in G2. The CCI was 0 to 2 in 41.2%, 3 to 4 in 44.5%, and ≥ 5 in 14.3% of patients. Figure 2 presents the flowchart of the study.

The characteristics of the study population, stratified by OSA severity, were summarized in Table 1. The distribution of patients according to OSA severity was not uniform, with the majority classified as severe. Specifically, 51.6% of patients had an AHI ≥ 30 per hour, while 18.3% had moderate OSA, and 30.1% had mild OSA. Severe excessive daytime sleepiness was noted in 16.4% of patients. Overweight was found in 87% of patients. The CCI was statistically associated with OSA severity ($p < 0.001$).

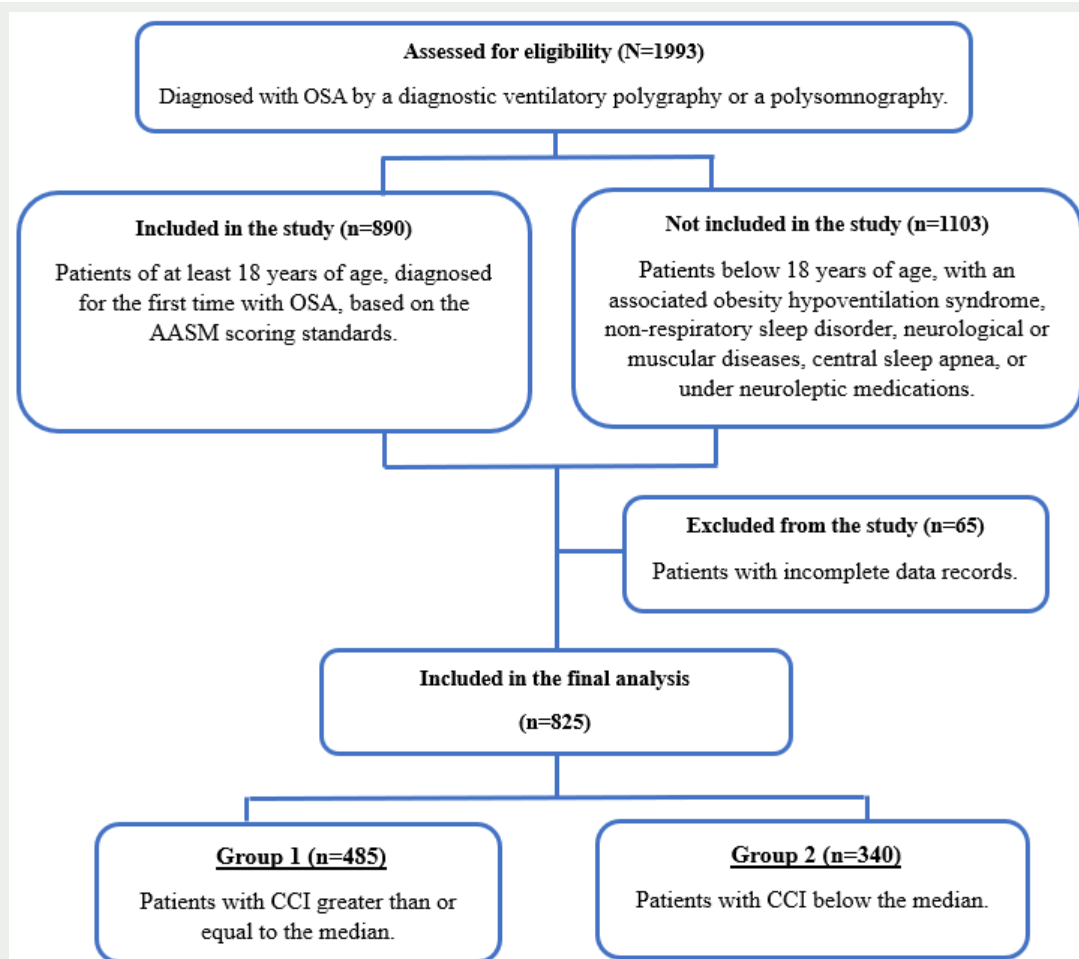


Figure 2. The flowchart of the study

AASM: American Academy of Sleep Medicine; CCI: Charlson Comorbidity Index; OSA: Obstructive sleep apnea

Table 1. The cohort characteristics by Obstructive Sleep Apnea severity

Characteristics	Total Cohort (N=825) Mean $\pm$ SD [Range]	Severe OSA (n=426) Mean $\pm$ SD	Non-severe OSA (n=399) Mean $\pm$ SD	p
Age (years)	56.9 $\pm$ 12.1 [18- 96]	58.6 $\pm$ 11.8	55.1 $\pm$ 12.2	<0.001
Female (%)	72	51	49	0.298
Smoking (%)	19	55	45	0.407
Body Mass Index (kg/m ²)	36.5 $\pm$ 7.4 [21.4 - 47]	37.5 $\pm$ 7.9	35.6 $\pm$ 6.7	<0.001
Stop Bang score (0-8)	4.3 $\pm$ 2 [0 - 8]	4.68 $\pm$ 2.4	4.09 $\pm$ 1.7	0.016
Epworth Sleepiness Scale (0-24)	10.7 $\pm$ 5.8 [0 - 24]	11.4 $\pm$ 5.7	10.1 $\pm$ 5.8	0.001
Pichot's Fatigue scale (0-32)	17.05 $\pm$ 8.4 [0 - 32]	18.2 $\pm$ 8.6	16.2 $\pm$ 8.2	0.014
Systolic blood pressure (mmHg)	130 $\pm$ 19 [90 - 210]	130 $\pm$ 17	120 $\pm$ 21	0.27
Diastolic blood pressure (mmHg)	75.5 $\pm$ 13 [30 - 150]	74 $\pm$ 11	76 $\pm$ 16	0.021
Fasting blood glucose (mmol/l)	6.4 $\pm$ 2.6 [3 - 22]	6.5 $\pm$ 2.7	6.3 $\pm$ 2.5	0.213
Arterial oxygen pressure (mmHg)	84.4 $\pm$ 18.5 [70 - 88.2]	83 $\pm$ 15.2	86 $\pm$ 21.5	0.027
Apnea Hypopnea Index (events/hour)	36.1 $\pm$ 22 [5.1 - 163]	49.1 $\pm$ 28.1	22 $\pm$ 10	<0.001
Oxygen desaturation index (events/hour)	30.7 $\pm$ 23.1 [0 - 164]	45.7 $\pm$ 22.3	14.4 $\pm$ 8.7	<0.001
Mean pulse oxygen saturation during sleep (%)	93 $\pm$ 6.1 [50 - 98.5]	90.6 $\pm$ 6.7	95.8 $\pm$ 2.4	0.103
Minimum pulse oxygen saturation during sleep (%)	77.1 $\pm$ 10.6 [40 - 94.7]	72.7 $\pm$ 11.4	82 $\pm$ 6.8	<0.001
Total recording time with saturation <90% (%)	15.4 $\pm$ 22.4 [0 - 99.8]	22.9 $\pm$ 26.1	7.1 $\pm$ 16.1	<0.001
Mean apnea duration (seconds)	18.9 $\pm$ 10 [0 - 82.1]	19.5 $\pm$ 7.5	18.1 $\pm$ 11.7	0.071
Mean hypopnea duration (seconds)	23.1 $\pm$ 5.9 [0 - 55.9]	22.1 $\pm$ 5.1	24.2 $\pm$ 6.6	<0.001
Charlson comorbidity index (0-37)	2.8 $\pm$ 1.6 [0 - 11]	3.1 $\pm$ 1.7	2.6 $\pm$ 1.5	<0.001

mmHg: millimeters of mercury; mmol/l: millimoles per liter; OSA: Obstructive sleep apnea; SD: Standard deviation

Table 2 showed the relationships between the CCI and OSA severity parameters. OSA severity parameters or predictors were defined as the variables from Table 1 that demonstrated statistically significant differences ($p < 0.05$) across severity groups.

A CCI ≥ 3 was significantly associated with age, Stop Bang score, diastolic blood pressure, arterial oxygen pressure, ODI, minimum nocturnal SpO₂, and total time with nocturnal SpO₂ $< 90\%$. In contrast, no significant associations were observed between the CCI and the AHI or the ESS.

Table 2. Statistical association between the Charlson Comorbidity Index and Obstructive Sleep Apnea severity predictors in univariate analysis

OSA severity predictors	G1 (n=485)	G2 (n=340)	<i>p</i>
Age (years)	63	47	<0.001
Body mass index (kg/m ²)	36.4	37	0.346
Stop Bang score (0-8)	5	4	0.003
Epworth Sleepiness Scale (0-24)	11	10	0.403
Pichot's Fatigue scale (0-32)	18	16	0.119
Diastolic blood pressure (mmHg)	80	70	0.023
Arterial oxygen pressure (mmHg)	82	86	0.009
Apnea Hypopnea Index (events/hour)	38	33	0.115
Oxygen desaturation index (events/hour)	32	28	0.022
Minimum pulse oxygen saturation during sleep (%)	76	78	0.005
Total recording time with saturation $< 90\%$ (%)	17	13	0.046
Mean hypopnea duration (seconds)	23	22	0.459

G1: Group1 (CCI ≥ 3); G2: Group 2 (CCI < 3); mmHg: millimeters of mercury; OSA: Obstructive sleep apnea

The multivariate analysis showed that age, Pichot's Fatigue scale, and minimum SpO₂ during sleep were independent factors of CCI greater than or equal to 3 (table 3).

Table 3. Independent factors of Charlson Comorbidity Index greater than or equal to 3 in multivariate analysis

OSA severity predictors	<i>P</i>	OR	CI 95%
Age (years)	<0.001	1.408	[1.270; 1.562]
Pichot's Fatigue scale (0-32)	0.017	1.082	[1.014; 1.155]
Minimum pulse oxygen saturation during sleep (%)	0.048	1.328	[1.002; 1.759]

CI: Confidence Interval; OR: Odds Ratio (Exp (B)); OSA: Obstructive sleep apnea

The ROC analysis (figure 3) showed that the CCI had an AUC of 0.6 (95% Confidence Interval: 0.56 – 0.64) for identifying severe OSA ($p < 0.001$). The optimal cutoff according to the Youden index was CCI ≥ 3.5 , with a sensitivity of 40% and specificity of 76%. However, for screening purposes, a lower cutoff of CCI ≥ 2.5 provided higher sensitivity (66%) at the expense of specificity (49%), with a positive predictive value of 58% and a negative predictive value of 57%.

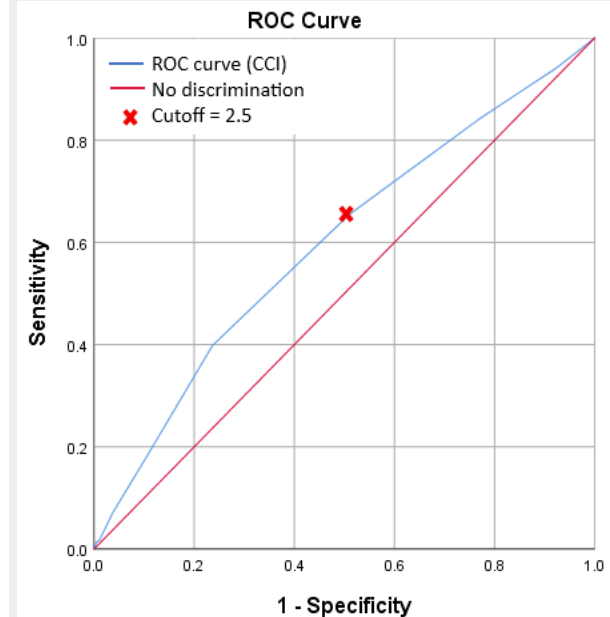


Figure 3. ROC Curve of the Charlson Comorbidity Index (CCI) for identifying severe Obstructive Sleep Apnea

DISCUSSION

Data of 825 patients were retrospectively collected and used to calculate the CCI.

Our Tunisian cohort presented unusual features. A predominantly female OSA population was highlighted and contrasted with the literature founding, as OSA is a known male gender associated condition (24). OSA in women seems to have some distinguished characteristics (25). It appears to be associated with specific anatomical factors such as greater obesity, a narrower oropharyngeal junction, a shorter soft palate, and reduced upper airway collapsibility compared to men (25). Indeed, this finding align with our observation, as 87% of the patients in our population were overweight.

OSA is a highly prevalent condition and considered the most common sleep-related breathing disorder affecting approximately one billion people worldwide (26,27).

OSA is a potentially severe condition associated with a poorer quality of life, higher cardiometabolic risk, more occurrence of vehicle accidents, and more frequent and costly healthcare use (28). Despite being a medical and financial burden from the individual to the population level, OSA remains underdiagnosed (27). Multiple factors were recognized to influence OSA diagnosis delay (26). Within these factors, the timing of referral for diagnostic testing was identified as a key delaying factor (29). In addition, Shang et al. (30) reported that the limited resources related to health system organization prolonged the patient's diagnosis delay to a certain extent, especially in underdeveloped countries.

Addressing these factors may be the most effective way to reduce OSA impact and burden, by challenging an early diagnosis and management approach. In fact, Canadian clinical practice guidelines suggest a maximum wait time of 6 months for investigation of suspected OSA, and the

AASM recommends a maximum wait time of 2 months for OSA severity confirmation (28). Pelletier-Fleury et al. (31) stated that an immediate polysomnography, as opposed to waiting for 6 months, provided greater improvements in symptoms and quality of life at the 6-month mark, and proved to be cost-effective.

Exploring alternative approaches for diagnosis and treatment initiation appears essential. Other more simple, accessible, reproducible, and rapid means than ventilatory polygraphy or polysomnography, may be favored as first-line tools to identify the most severe cases, which should be prioritized for swift diagnosis and management (32).

As known, OSA is highly associated with multiple comorbidities which further worsens its morbi-mortality, and the IAH is associated with serious coexisting conditions (33). Thus, finding suitable tools to assess comorbid conditions may be useful to predict OSA severity (33). Among multiple tools, the CCI seems to be promising. The CCI is known to be used to assess the impact of comorbidities on various chronic diseases outcome (7). The CCI was used by Ntenta et al. (34), and by Carratù et al. (35) in their studies for comorbidity assessment in OSA patients.

We conducted this study using the CCI to evaluate its ability to predict OSA severity, and assess its potential as a tool for prioritizing the diagnosis and treatment of patients with the most severe and urgent conditions.

Our results indicated that $CCI \geq 3$ was associated statistically to age, Stop Bang score, diastolic blood pressure, glycemia, arterial oxygen pressure, ODI, minimal nocturnal SpO₂, and nocturnal SpO₂ below 90%. And a $CCI \geq 3$ was associated to a worse ESS, Pichot score, BMI, AHI, mean duration of hypopnea or apnea, and mean nocturnal SpO₂. Our results were aligned with the literature, as all these parameters excluding the Pichot score, were associated with OSA severity defined by the AHI according to AASM scoring (36). According to Milicic Ivanovski et al., the CCI was significantly higher not only in OSA group compared to control group, but also in severe OSA group (36). In fact, since the CCI is known to better reflect mortality risk, it is expected to have a stronger correlation with OSA severity, particularly in relation to cardiovascular and metabolic comorbidities (37). Other studies evaluated the contribution of the CCI in other chronic diseases, as in patients with type 2 diabetic nephropathy, where the CCI proved to help predict the risk of mortality (37). In patients with acute myeloid leukemia, the CCI proved its usefulness in predicting early mortality and overall survival in older patients (38).

Aside from the CCI, another promising tool, the Functional Comorbidity Index, was developed and validated in 2005 by Groll et al. (39). Indeed, the Functional Comorbidity Index is known to be more closely related to the impact of OSA on daily living and physical function and may be more useful if focused on how OSA affects the patient's daily functioning (39).

In conclusion, the CCI showed a statistically significant but modest discriminative ability to identify severe OSA, with variable associations across OSA severity predictors. A cutoff of 3.5 maximized specificity, while a lower threshold of 2.5 improved sensitivity for screening, albeit with

more false positives. These findings suggest that the CCI is a promising tool for detecting the most severe cases, thus may help identify high-risk patients who should be prioritized for rapid diagnosis and management.

Further research is needed to refine tools for phenotyping OSA patients according to comorbidity and severity by integrating the CCI with clinical measures such as the ESS and fatigue scores. It is also important to differentiate how major comorbidities influence OSA severity and manifestations, ultimately supporting more personalized treatment strategies.

GLOSSARY:

AASM: American Academy of Sleep Medicine

AHI: apnea hypopnea index

AUC: Area under the curve

BMI: body mass index

CCI: Charlson Comorbidity Index

ESS: Epworth sleepiness scale

G1: Group 1

G2: Group 2

ODI: oxygen desaturation index

OSA: Obstructive sleep apnea

ROC: Receiver Operating Characteristic

SpO₂: arterial oxygen saturation

STOP Bang: snoring, tiredness, observed apnea, high BP, BMI, age, neck circumference, and male gender questionnaire

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