Accuracy of a New Algorithm to Identify Asthma–COPD Overlap (ACO) Patients in a Cohort of Patients with Chronic Obstructive Airway Disease

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Abstract
Objectives: We aimed to characterize the clinical, functional and inflammatory features of patients diagnosed with ACO according to a new algorithm and to compare them with those of other chronic obstructive airway disease (COAD) categories (asthma and COPD).
Methods: ACO was diagnosed in a cohort of COAD patients in those patients with COPD who were either diagnosed with current asthma or showed significant blood eosinophilia (≥300 cells/μl) and/or a very positive bronchodilator response (>400 ml and >15% in FEV1).
Results: Eighty-seven (29.8%) out of 292 patients fulfilled the ACO diagnostic criteria (12.8% asthmatics who smoked <20 pack-years, 100% of asthmatics who smoked ≥20 pack-years, 47.7% of COPD with >200 eosinophils/μl in blood and none with non-eosinophilic COPD). ACO, asthma and COPD patients showed no differences in symptoms or exacerbation rate. Mean pre-bronchodilator FEV1 in ACO and asthma were similar (1741 vs 1771 ml), higher than in COPD (1431 ml, p < 0.05). DLCO was lower in ACO than in asthma (68.1 vs 84.1%) and similar to COPD (64.5%). Mean blood eosinophil count was similar in ACO and asthma (360 vs 305 cells/μl) and higher than in COPD (170 cells/μl). Periostin levels were similar in ACO to COPD (36.6 and 36.5 IU/ml) and lower than in asthma (41.5 IU/ml, p < 0.05), whereas FeNO levels in ACO were intermediate.
Conclusion: This algorithm classifies as ACO all smoking asthmatics with non-fully reversible airway obstruction and a considerable proportion of e-COPD patients, highlighting those who can benefit from inhaled corticosteroids.

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Precisión de un nuevo algoritmo para identificar pacientes con superposición asma/EPOC (ACO) en una cohorte de pacientes con enfermedad obstructiva crónica

Resumen
Objetivos: Nuestro objetivo fue definir las características clínicas, funcionales e inflamatorias de los pacientes diagnosticados con superposición asma/EPOC (ACO, por sus siglas en inglés) según un nuevo algoritmo y compararlas con las de otras categorías de enfermedades obstructivas crónicas de las vías aéreas (COAD, por sus siglas en inglés) como el asma y la EPOC.

Palabras clave:
Asma
Enfermedad pulmonar obstructiva crónica
Superposición asma-Enfermedad pulmonar obstructiva crónica

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Introduction

Asthma and chronic obstructive pulmonary disease (COPD) are both common, heterogeneous and usually distinct airway diseases that sometimes overlap in a particular patient. This entity, the so-called asthma–COPD overlap (ACO) has attracted attention and triggered debate in recent years as evidenced by the proliferation of reviews and editorials dedicated to the topic.\(^2\)\(^-\)\(^7\) GOLD and GINA define ACO as persistent airflow limitation with several features usually associated with asthma and other usually associated with COPD, and specifies that ACO encompasses different features that are likely clinical expressions of distinct underlying mechanisms.\(^8\) Although this approach is intuitive, it is also quite imprecise because it does not take into account the relevance of each criterion for the diagnosis of ACO and it may not be useful in daily clinical practice.

ACO is difficult to define due to the lack of understanding of the underlying inflammatory mechanisms and, nowadays, it is an umbrella term that encompasses patients with COPD and eosinophilic inflammation, and smoking asthmatics with irreversible airway obstruction. In this climate of uncertainty, it is not surprising that the diagnosis of this entity remains elusive, with no defined clinical or functional criteria universally accepted. We have recently shown that ACO’s manifestations are somewhere in between COPD and asthma, since these patients showed analogous demographic and inflammatory characteristics to those with asthma and functional impairment and the presence of comorbidities similar to those included in the COPD group.\(^9\)

In this context, the Spanish Society of Pneumology and Thoracic Surgery (SEPAR) recently developed a new strategy for the identification of ACO by incorporating the new evidence generated over the last years.\(^10\) The objective was to provide a simple and clear guideline for clinicians to help them in the identification of this entity among patients with chronic obstructive airways disease (COAD). This algorithm first requires the diagnosis of COPD based on current guidelines.\(^11\) Once the diagnosis of COPD is established, the patient can be labelled as having ACO if a current and objectively established diagnosis of asthma is present. If this is not the case, the presence of one or two markers of Th2 inflammation – a very positive bronchodilator response (>400 ml and >15% in FEV1) and/or a significant blood eosinophilia (>300 cells/μl) – also enables the diagnosis of ACO.\(^10\)

The aim of this study was to differentially characterize patients diagnosed with ACO according to the new SEPAR's algorithm from patients with other COAD categories (asthma and COPD patients who do not meet criteria for ACO). The characterization was made according to clinical, functional and inflammatory features and, as a secondary end-point, we assessed these variables – in solo or in combination – capacity to distinguish ACO from asthma and COPD patients without ACO.

Material and methods

Study design

This was a multicentre and cross-sectional study. The SEPAR-ACO algorithm was applied in the CHACOS cohort of COAD patients, which has already been the subject of preliminary study.\(^9\) Briefly, patients aged >40 years with chronic airflow obstruction (post-bronchodilator FEV1/FVC < 0.70) and a history of physician-diagnosed asthma (non-smoking or smoking asthmatics), or COPD (non-eosinophilic or eosinophilic) who signed an informed, written consent form, were included. Patients had to be in a stable condition, free from exacerbations for at least 3 months. Exclusion criteria included primary bronchiectasis, active cancer (metastatic, progressive, or treated within the last 24 months), chronic inflammatory diseases and poor performance status.

The study was conducted in a single visit in which the researchers obtained and recorded all the clinical data into an electronic clinical research database. A blood sample was obtained to determine the number and percentage of blood eosinophil and quantification of immunoglobulin E (IgE). All investigators were asked to prospectively recruit 12 consecutive patients with COAD from their clinics: 8 belonging to the non-eosinophilic COPD and non-smoking asthma categories, and 4 belonging to the other two (Fig. 1). The study was approved by the Research Ethics Committee of the Balearic Islands (Cod: IB2499/15). Additionally, an independent Ethics committee or institutional review board for each study centre approved the final protocol.

Definitions

Chronic obstructive airway disease (COAD): patients with a FEV1/FVC post-bronchodilator <70%, regardless if it comes from COPD or asthma.

Asthma was diagnosed according to international guidelines,\(^8\) and was classified as non-smoking asthmatics (NSA): asthma patients -non-smokers or ex-smokers- with smoking history of <20
Patients > 40 yr and post-bronchodilator FEV\textsubscript{i}/FVC < 70%

Previous diagnosis of asthma

Smoker >20 pack-years

Blood eosinophils > 200 cel/µL

ACO

COPD-e

Fig. 1. Patient recruitment flow diagram.

Pack-years; or smoking asthmatics (SA): asthma patients with smoking history of >20 pack-years.

COPD was diagnosed – according to international recommendations\textsuperscript{1,2} – by the presence of post-bronchodilator FEV\textsubscript{i}/FVC < 0.70 in patients with smoking history of >10 pack-years in the absence of a clinical suspicion for asthma. COPD with eosinophilia (COPD-e) was considered in COPD patients with eosinophil count >200 eosinophil/µl in blood. We selected this threshold to recruit the patients because below this cut-off patients are unlikely to have sputum eosinophilia, according to published evidence\textsuperscript{13,14}.

ACO. Patients classified as ACO according to SEPAR-ACO algorithm\textsuperscript{10} (Fig. 2).

Measurements

More detailed information about data management, pulmonary function tests, fractional exhaled nitric oxide (FeNO) measurement and sputum induction can be found elsewhere\textsuperscript{9}. Periostin blood levels were measured using a streptavidin-HRP ELISA commercial kit (DuoSet\textsuperscript{®} ELISA, R&D Systems, Minneapolis, MN, USA), according to the manufacturer’s instructions.

Statistical analysis

Categorical variables were summarized by means of group counts and percentages, normally distributed continuous variables by the distribution mean and Standard Deviation and non-normally distributed continuous variables by means of the median and the inter-quartile range.

One-way ANOVA was used to compare normally distributed continuous variables between the 3 clinical categories. Non-parametric Kruskal–Wallis ANOVA was used for continuous parameters without a normal distribution, while Chi-square test was applied to compare group proportions. Student’s t tests, Mann–Whitney U test and Chi-square with the appropriate Bonferroni correction were used for pair-wise comparisons.

The ability of all the studied parameters and their combinations to discriminate between ACO and the other categories
was assessed by estimating sensitivity, specificity, positive and negative predicted values, Youden index (Youden index = sensitivity + specificity – 1), the corresponding ROC curves and the 95% CIs.

Results

Population characteristics

Two hundred and ninety-two patients with COAD were included in the study: 94 NSA, 89 COPD, 44 SA and 65 COPD-e. Eighty-seven (29.8%) of them fulfilled the SEPAR-ACO diagnostic algorithm (12.8% of NSA, 100% of SA, 47.7% of COPD-e and none of COPD).

By definition, all these 87 patients fulfilled criteria for COPD and 56 had a concomitant diagnosis of “current asthma”. 12 showed a “very positive” bronchodilator response and 45 displayed ≥ 300 eosinophils/μL. The interrelationship of the features needed to diagnose ACO according to SEPAR-ACO algorithm is illustrated in a Venn diagram (Fig. 3).

In the whole cohort, the degree of bronchial obstruction was moderate and symptoms were fairly well-controlled as assessed by the CAT and ACT questionnaires. The average number of exacerbations in the course of the previous 12 months was 1.0. Most patients (80%) were being treated with inhaled corticosteroids (ICS) and almost all of them received a long-acting β2-agonist (LABA). About 71% were being treated with a long-acting muscarinic antagonist (LAMA). Nearly 2% of the patients were receiving oral corticosteroids and 8.9% were being treated with omalizumab.

Fig. 3. Nonproportional Venn diagram showing the interrelationship of ACO’s criteria. Asthma means “current diagnosis” of the disease; ++ means “very positive” bronchodilator test.

Accuracy of different clinical, functional or inflammatory variables, separately or in combination, to identify ACO in a cohort of patients with COAD

Neither a single variable, nor any combination of them yielded enough sensitivity and specificity to accurately identify ACO. The area under the ROC curve (AUC) was <0.7 in every case. Table 2 displays the AUCs for each variable and combinations. When we evaluated the accuracy of the same variables to distinguish between ACO and asthma, and to differentiate between ACO and COPD, the results lacked enough rentability (Table 2).

Discussion

In this study, we have found that SEPAR-ACO algorithm classifies in the ACO category all patients diagnosed with asthma who smoked and developed a fixed bronchial obstruction and almost a half of “eosinophilic COPD”. The definition of “eosinophilic COPD” depends on a somewhat arbitrary cut-off point of blood eosinophil count: 200 cells/μL in this cohort of COAD patients and 300 cells/μL in the proposed algorithm (it is for this reason why not every patient with “eosinophilic COPD” was classified as ACO). There is controversy about the exact blood eosinophils’ cut-off point that better reflects airway eosinophilia: Negewo et al. observed that patients are unlikely to have sputum eosinophilia if their blood eosinophil count is below 200 cells/μL whereas Schleich et al. set this point at 162 cells/μL to identify a sputum eosinophil count >5% and 215 cells/μL in those treated with high dose of ICS. On the other hand, Kolsum et al. found that >250 eosinophils/μL in blood reliably reflect lung eosinophilia. Whatever the exact limits are, it seems clear that eosinophilic COPD appears to be a distinct patient subgroup with a different inflammatory signature and a better response to corticosteroid treatment. It is therefore reasonable to separate this subgroup from “non-eosinophilic COPD”
and to include it in the ACO’s category, because it will ensure a therapeutic approach based on the use of ICS combined with bronchodilators and even biological drugs in a near future. However, we should take into account that SEPAR-ACO algorithm also encompasses patients with COPD and a current diagnosis of asthma, and it has been shown that these patients exhibit more atopic features,
have better pulmonary function and they form a more heteroge-
neous group from the inflammatory point of view than e-COPD
patients, including a significant proportion of subjects with a "Th2-
low" pattern. This could be explained by the fact that the concept
"COPD and a current diagnosis of asthma" relies on clinical charac-
teristics (asthma diagnosis and smoking history) whereas e-COPD
definition includes a biomarker of Th-2 inflammation.

Woodruff et al. have shown that lung function improvements
expected with ICSs were restricted to Th2-high asthma so, it is not
unreasonable to speculate that not every asthma patient will need
treatment with ICSs. However, in our opinion, it seems far too early
to deprive asthma patients from ICSs at the present time and the
most sensible option is to maintain this subgroup under the ACO
definition.

Besides current diagnosis of asthma and blood eosinophilia,
SEPAR-ACO’s algorithm also considers a "very positive bron-
chodiator response" as a diagnostic criterion, since it has been
published that a Th2 gene signature correlates with bronchodila-
tor reversibility. However, no patient in our study was labelled
as having ACO on the basis of a "very positive bronchodilator
response" as a single diagnostic feature, because all patients with
this characteristic showed either current asthma diagnosis or high
blood eosinophilia.

Recently, Sinn and colleagues made an alternative proposal to
identify ACO. If we apply their proposed criteria in our cohort, we
might classify in this category 11.7% of NSA group patients, 5.6% of
COPD group patients, 77.3% of the SA group patients and 12.3% of
COPD-e patients. Therefore, these criteria mainly identify as ACO
asthmatics who have smoked and developed a "fixed bronchial
obstruction", but they set aside most patients with eosinophilic
COPD. Since definitions of ACO vary across the different studies and
expert recommendations, the most appropriate would be the one
that includes more common "treatable traits", enabling the clinici-
án to accurately prescribe ICSs in a particular patient and, thus,
providing a more personalized therapeutic approach.

We have been unable to find clinical, functional or inflamma-
tory variables – in solo or combined – capable of distinguishing ACO
patients from other categories of COAD, beyond those included in
the definition. This probably underscores the complexity and the
great patient-to-patient variability of all forms of COAD, a fact that
was already highlighted by other authors. Apart from the arbi-
trariness of the blood eosinophil’s cut-off point to define e-COPD –
pointed out above – some other limitations deserve a comment. A
large number of patients were receiving medications able to modify
the expression of parameters like blood eosinophils and FENO (e.g.
omalizumab and oral corticosteroids). In addition, we have chosen
a limit of 20 pack-years of smoking exposure to define SA category
and we recognize that it could be misleading, but we wanted to
make sure that smoking-related inflammation is present in indi-
viduals with previous asthmatic inflammation.

In conclusion, the SEPAR-ACO consensus algorithm classifies
as ACO all smoking patients with previous history of asthma who
developed fixed bronchial obstruction and a considerable
proportion of COPD patients with >300 cells/μL, but apparently
the criterion of high reversibility does not identify ACO patients
by itself. SEPAR-ACO algorithm has the advantage that identifies
patients who can benefit from treatment with ICS.

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Authors contributions

LPLL and BC made substantial contributions to conception and
design of the study, and analysis and interpretation of data. They
have both been involved in drafting the manuscript and revising it
critically for important intellectual content. MM and VP have
both been involved in drafting the manuscript and revising it crit-
ically for important intellectual content. All authors have read and
approved the final manuscript.

Conflict of interest

The authors declare that they have no conflicts of interest related
to this study.

Appendix 1

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Appendix 2. Supplementary data

Supplementary data associated with this article can be found, in

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