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Original article

Hoover's sign is a predictor of airflow obstruction severity and is not related to hyperinflation in chronic obstructive pulmonary disease ☆

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ABSTRACT

Background: Several phenotypes are described in COPD.
Objectives: To assess if COPD patients with Hoover's sign (HS) belong to a particular phenotype.
Methods: All consecutive COPD patients with varying degree of airflow obstruction that came for lung function testing in one university hospital were prospectively assessed, using clinical and magnetometer detection of HS, body mass index (BMI), St. George's Respiratory Questionnaire for health-related quality of life, six-minute-walk test (6MWT) with inspiratory capacity (IC) measurements and expiratory flow limitation (EFL) detection. Previous exacerbations were also reported.
Results: 82 patients were studied. Magnetometers confirmed HS in 56 of them, of which 79% (44/56) were detected by clinical assessment. HS (+) patients were older (64 ± 10 vs 59 ± 10 years, p = 0.03), had a higher BMI (26 ± 5 vs 23 ± 4, p = 0.04), a lower FEV1 (53% ± 18% vs 63% ± 18% pred, p = 0.02) and a higher IC decrease at the end of 6MWT, (−19 ± 2 vs −7 ± 4% pred, p = 0.003). A larger proportion of HS (+) patients also reported severe exacerbations during the past 2 years (39% vs 12% p = 0.01). There was no statistical evidence that HS was related to hyperinflation and/or EFL.
Conclusion: The very simple clinical HS allows identifying a particular population of COPD patients of older age and higher BMI with a more severe airflow obstruction, increased dynamic hyperinflation during exercise and higher exacerbation frequency. These characteristics were not linked to hyperinflation or EFL.

1. Introduction

Severity of chronic airway obstruction is mostly appreciated by GOLD classification [1]. FEV1, FVC and FEV1/FVC ratio however contributes to less than 25% of the disease impact on symptoms, quality of life and exercise performance [2–4] and it is then important to identify other disease attributes that may affect clinical outcomes. A better phenotyping may be performed using various parameters, including symptoms, radiography, physiological, molecular or cellular characteristics [5].

In COPD patients, various clinical signs including abnormalities of chest wall motion have been described, and among them, Hoover's sign (HS) is the oldest. HS is defined as an inward motion of the lateral diameter of the lower rib cage during part of or all the inspiratory phase.

Hoover gave his name to this sign [6] but it has been earlier described [7,8] and remains the commonest and the more easily recognizable [9]. This sign has been attributed to direct diaphragmatic traction on the lower rib cage margin, when the diaphragm is flattened in conditions of hyperinflation [10]. Since hyperinflation has been shown to be related to functional impairment in COPD [11], we reasoned that patients with Hoover's sign might share a particular phenotype. With this in mind, we have prospectively studied a population of COPD patients with various degrees of airway obstruction and assessed the presence/absence of the HS as well as their quality of life, body mass index (BMI), exercise performance and exacerbations during the previous years. We also assessed whether this clinical sign is linked to static/dynamic hyperinflation and expiratory flow limitation (EFL).

2. Methods and materials

2.1. Patients

From Sep 2006 to Dec 2007, all stable COPD patients GOLD stages I to IV [1] that came ambulatory for lung function testing in our clinic were prospectively studied. They were selected on the basis of medical history, smoking habits and plethysmographic results showing a FEV1/FVC ratio below 70%. They were in clinically stable condition (at least 1 month without exacerbation, defined as mild, if requiring antibiotics; moderate if requiring parenteral corticosteroids +/− antibiotics; and severe, very severe or life-threatening if associated with any degree of

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respiratory failure [12]). All subjects gave informed consent to the procedures as approved by the Human Studies Committee of the institution.

2.2. Measurements

2.2.1. First evaluation immediately after lung volume measurements

Medical history, including severe exacerbations listing and quality of life evaluated by the St. George's Respiratory Questionnaire (SGRQ) [13] was collected. Hoover's sign was first assessed clinically using inspection and palpation while the patient was comfortably seated in an armchair and breathing quietly. A random group of patients was also assessed for HS by 2 different investigators that were each blind to the diagnosis of the other. Thereafter, a pair of linearized magnetometers (Van Herle, Brussels, Belgium) was attached laterally, in the mid-axillary line on the costal margin, in order to confirm respiratory changes in the lateral dimensions of the lower rib cage [14,15]. Simultaneously, changes in flow and lung volumes were measured while the subject was breathing throughout a mouthpiece, wearing a nose clip, in order to precise the phases of breathing. After 1 min, when breathing seemed stable, measurements were performed during at least 1 min and all signals were recorded on an eight-channel recorder (type WR3801; Graphtec Corp Tokyo, Japan). For the purpose of analysis, HS was defined as an inward motion of the lateral diameter of the lower rib cage during part of or all the inspiratory phase and patterns such as complete paradoxical motion, delayed phase paradoxical motion or biphasic paradoxical rib cage motion were all considered as positive.

The same day, a first six-minute-walk test (6MWT) (habituation test) following the ATS guidelines [16] was performed.

2.2.2. Second evaluation

During the same week, patients were restudied for EFL assessment, inspiratory capacity (IC) measurements before and after a second 6MWT. EFL was detected using the Manual Compression of the Abdomen (MCA) manoeuvre, as previously described [17]. At least three MCA manoeuvres were performed in each subject, and separated by interval of time lasting at least 2 min. Airflow and volumes were measured using a pneumotachograph (Spiro BT100, Medical Electronic Construction, Brussels, Belgium) and EFL was considered whenever MCA could not elicit increases in expiratory flow during part of or all the expiratory phase [17].

IC measurements were then performed at rest, while the patients were seated. Patients were initially instructed on the performance of the IC manoeuvre with special attention to its methodology. After four to six consistent end-expiratory levels, they were instructed to inspire until total lung capacity (TLC), and then return to tidal breathing. These IC measurements were repeated until two corresponded to within 5% of each other and the best one was recorded for analysis [18]. Thereafter, the second 6MWT was completed and IC measurement was repeated immediately at the end of the walking test [18].

2.3. Statistical analysis

The Kappa coefficient was used to determine the agreement between two examiners, and a 95% confidence interval was calculated. The χ^2 test and Fisher's exact test were used to test the statistical significance of differences in discrete data; student's t-test and Mann–Whitney's test were used to test the statistical significance of differences in continuous data. Multivariate logistic regression was performed with stepwise forward selection of variables using 0.05 as significance level of entry. Two-sided p values <0.05 were considered to indicate statistical significance.

3. Results

82 consecutive COPD patients were studied. They were all current smokers or ex-smokers and belonged to GOLD stages I to IV.

Magnetometers confirmed Hoover's sign in 56 of them (41 men, 15 women). Inspection and palpation confirmed the presence of HS in 79% (44/56), and the absence in 88% (23/26). 34 patients were examined by two investigators with an agreement of 91% (Kappa coefficient of 0.82 (95% CI, 0.63 to 1).

Table 1 summarizes various characteristics of COPD patients according to the presence or absence of the HS. On the average, COPD patients exhibiting HS (HS(+) group) had a similar sex distribution (73 vs 65% of men, $p=0.47$) but were older (64 ± 10 vs 59 ± 10 years, $p=0.03$), had a higher BMI (26 ± 5 vs 23 ± 4, $p=0.04$) and a lower FEV1 (53 ± 18 vs 63 ± 18% of the predicted value, $p=0.02$) than patients without HS. Regarding GOLD distribution, there were few patients in GOLD I and IV groups, and the distribution was similar ($p=0.06$) in HS(+) and HS(−) group. However, when pooling stages, there were more GOLD stages III or IV cases in the HS(+) group compared to HS(−): 46% vs. 19%: $p=0.03$. However, 54% of HS(+) patients belonged to GOLD stages I and II. Unexpectedly, no difference was found in TLC or FRC between the two groups (Table 1). The SGRQ total score was 7 units higher in the HS(+) group but this difference was not found to be significant (SGRQ total score: 44 ± 19 vs 37 ± 20, $p=0.15$). However, if we consider separately the 3 SGRQ items, the activity domain score was significantly worse in HS(+) than HS(−) patients (62 ± 21 vs 48 ± 26, $p=0.01$). A larger proportion of HS(+) patients also reported severe exacerbations during the past 2 years (39% vs 12%, $p=0.01$).

At the end of exercise (6MWT), the HS(+) group as a whole showed a larger decrease in inspiratory capacity than the HS(−) group (Delta IC: -0.56 ± 0.05 vs -0.33 ± 0.1 L, $p=0.09$, -19 ± 2 vs -7 ± 4% pred, $p=0.003$). The proportion of patients with HS(+) exhibiting EFL during

Table 1
Anthropometric and functional characteristics of COPD patients as a function of the presence/absence of Hoover's sign.

	Hoover's sign		p value
	Absent (N = 26)	Present (N = 56)	
Age, years	59 ± 10	64 ± 10	0.03
Sex			
F	9 (35)	15 (27)	0.47
M	17 (65)	41 (73)	
BMI	23 ± 4	26 ± 5	0.04
FEV1, L	1.87 ± 0.57	1.43 ± 0.53	0.001
FEV1, % pred	63% ± 18%	53% ± 18%	0.02
FRC, % pred	137% ± 29%	150% ± 44%	0.10
TLC, % pred	114% ± 21%	115% ± 20%	0.88
6MWT, m	499 ± 80	467 ± 92	0.13
6MWT, % pred	73 ± 13	72 ± 14	0.78
IC at rest, L	2.41 ± 0.71	2.15 ± 0.57	0.09
IC end 6MWT, L	2.18 ± 0.81	1.64 ± 0.49	0.01
Delta IC, L	0.33 ± 0.16	0.56 ± 0.05	0.09
Delta IC, % pred	7 ± 4	19 ± 2	0.003
SGRQ, total score	37 ± 20	44 ± 19	0.15
SGRQ, symptoms	44 ± 26	45 ± 21	0.91
SGRQ, activities	48 ± 26	62 ± 21	0.01
SGRQ, impact	25 ± 17	30 ± 20	0.23
Exacerbations, moderate			
0	17 (65)	29 (52)	0.25
1 or more	9 (35)	27 (48)	
Exacerbations, severe			
0	23 (88)	34 (61)	0.01
1 or more	3 (12)	22 (39)	
GOLD			
1	3 (12)	5 (9)	0.06
2	18 (69)	25 (45)	
3	3 (12)	22 (39)	
4	2 (8)	4 (7)	
EFL			
Absent	13 (50)	20 (36)	0.22
Present	13 (50)	36 (64)	

FEV1: forced expiratory volume in 1 s; FRC: functional residual capacity; TLC: total lung capacity, SGRQ: Saint George's Respiratory Questionnaire. 6MWT: six-minute-walk test; IC: inspiratory capacity; BMI: body mass index; EFL: expiratory flow limitation. Values are presented as mean ± SD unless otherwise indicated.