ORIGINAL ARTICLE

Assessment of the Bronchodilation Test by Visual Analog Scale in the Selection of Patients With Rhinitis for Screening Spirometry

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Abstract

Background: The nose and bronchi are closely linked, and rhinitis often precedes the onset of asthma. Bronchial obstruction is a characteristic of asthma, and demonstration of its reversibility is a key element in diagnosis. However, reversibility testing requires a spirometer, which is rarely available in the doctor's office. Visual analog scales (VAS) are frequently used in daily practice.
Objective: This study evaluated the suitability of a VAS for assessing bronchodilation in patients with persistent allergic rhinitis as a means of selecting candidates for screening spirometry.
Methods: We evaluated 120 patients with moderate to severe persistent allergic rhinitis. All patients underwent a clinical examination, skin prick test, spirometry, bronchodilation test, and VAS.
Results: Patients with rhinitis showed significantly increased forced expiratory volume in the first second (FEV_1) after the bronchodilation test (median, 11.5%). Positive results were observed in 60%, and VAS values increased (>30%) after the test. There was a significant relationship between ΔVAS and ΔFEV_1 ($P<.0001$; $r=0.482$).
Conclusion: This preliminary study shows that patients with moderate to severe persistent allergic rhinitis often experience an increase in FEV_1 after the bronchodilation test. VAS assessment of the test might be useful when selecting candidates for spirometry for possible bronchial involvement.

Key words: Allergic rhinitis. Asthma. VAS. Respiration. Spirometry. Bronchodilation.

Resumen

Antecedentes: La nariz y los bronquios están estrechamente relacionados, y la rinitis suele preceder a la aparición del asma. La obstrucción bronquial es una característica del asma, y la demostración de su reversibilidad es un elemento clave del diagnóstico del asma. No obstante, las pruebas de reversibilidad requieren un espirómetro, que raramente está disponible en la consulta del médico. En la práctica clínica diaria suelen utilizarse escalas analógicas visuales (EAV).
Objetivo: En este estudio se evaluó la idoneidad de la EAV para la evaluación de la broncodilatación en pacientes con rinitis alérgica persistente como medio de selección de candidatos para espirometría de cribado.
Métodos: Se evaluó a 120 pacientes con rinitis alérgica persistente moderada o grave. Todos los pacientes fueron sometidos a exploración física, prueba de punción cutánea, espirometría, prueba de broncodilatación y EAV.
Resultados: Los pacientes con rinitis mostraron un aumento significativo del volumen espiratorio máximo en el primer segundo (VEM_1) tras la prueba de broncodilatación (mediana, 11,5%). Se observaron resultados positivos en el 60%, y los valores de la EAV aumentaron (>30%) después de la prueba. Se observó una correlación significativa entre la diferencia (Δ) en la EAV y la diferencia en el VEM_1 ($p< 0,0001$; $r =0,482$).
Conclusión: Este estudio preliminar refleja que los pacientes con rinitis alérgica persistente moderada o grave suelen mostrar un aumento del VEM1 tras la prueba de broncodilatación. La evaluación mediante EAV de la prueba puede ser útil a la hora de seleccionar candidatos para la espirometría a fin de detectar una posible afectación bronquial.

Palabras clave: Rinitis alérgica. Asma. EAV. Respiración. Espirometría. Broncodilatación.

Introduction

Allergic rhinitis is characterized by typical symptoms induced by an immunoglobulin (Ig) E–mediated inflammatory response of the nasal mucosa to the allergen [1]. Therefore, inflammation is a key phenomenon in allergic rhinitis. Indeed, nasal eosinophil counts correlate well with symptoms and respiratory function [2]. Asthma is defined as a chronic inflammation of the lower airways [3] that can limit airflow in the nose and the bronchi [4], and a close link between allergic rhinitis and asthma has been widely reported [5,6]. Moreover, allergic rhinitis has proven to be an important risk factor for the onset of asthma [7].

The airflow obstruction that characterizes asthma [8,9] is easily assessed by spirometry. Several parameters are useful, but the gold standard is forced expiratory volume in the first second (FEV_1) [3]. Reversibility of airflow obstruction is highly desirable and may be spontaneous or induced by drugs such as bronchodilators. The bronchodilation test is usually performed to demonstrate the reversibility of bronchial obstruction and thus confirm the diagnosis of asthma.

As allergic rhinitis may precede asthma or is frequently associated with it, the WHO document "Allergic Rhinitis and its Impact on Asthma" (ARIA) [4] clearly underlines the role of allergic rhinitis as a risk factor for the development of asthma and recommends that bronchial involvement be investigated in patients with allergic rhinitis. One epidemiological study has reported that FEV_1 may be impaired in about 5% of patients with nasal symptoms alone [10].

Moreover, slightly altered spirometric values, such as reduced forced expiratory flow, midexpiratory phase (FEF_{25-75}), could be very common in patients with rhinitis and may even be a reliable marker of early bronchial involvement [11].

A recent study showed that patients with moderate to severe persistent allergic rhinitis but normal spirometry values often show reversibility to the bronchodilation test [12]. This may indicate early bronchial involvement, as the patients had nasal symptoms alone. Reversibility was also associated with low—yet normal—baseline FEV_1 values, longer duration of rhinitis, and sensitization to mites, trees, or both [12]. Thus, the bronchodilation test could prove useful in screening. However, although they are easy to perform, both simple spirometry and the bronchodilation test require the use of a spirometer, which is rarely present in the doctor's office. Consequently, these tests are seldom performed in routine clinical practice. In addition, epidemiology surveys report that up to 40% of the general population suffers from allergic rhinitis [4].

Visual analog scales (VAS) have recently been proposed as a useful parameter in assessing symptoms in patients with allergic rhinitis [13]. These scales have been validated for many diseases: in fact, VAS of sensory intensity and affective magnitude were validated as ratio scale measures for chronic and experimental pain [14]. They have also been extensively applied to assess the severity of rhinitis and the efficacy of therapy [13].

This study evaluates VAS as a simple tool for screening patients with allergic rhinitis who are at risk of bronchial involvement. We administered the bronchodilation test to patients with persistent allergic rhinitis in order to select candidates for spirometry.

Materials and Methods

Study Population

The study population comprised 120 consecutive patients with moderate to severe persistent allergic rhinitis who underwent skin prick testing, VAS assessment, spirometry, and the bronchodilation test. Demographic characteristics—gender, age, and duration of rhinitis (expressed in years)—are reported in the Table. All the participants were sailors referred to the Navy Hospital for a mandatory medical examination to maintain their rank. The Navy ethics committee approved the study methodology and participants gave their informed written consent.

Table. Characteristics of the Study Patients (N=120)[a]

Characteristics	
Females, No. (%)	30 (25%)
Age, y	24 (19-29)
Duration of rhinitis, y	3 (1-12)
Pretest VAS	5 (3-8)
Pretest FEV_1, % of predicted	89 (80-109)
Pretest FVC, % of predicted	101.5 (77-116)
Pretest FEF_{25-75}, % of predicted	71 (56-79)

Abbreviations: FEF_{25-75}, forced expiratory flow, midexpiratory phase; FEV_1, forced expiratory volume in the first second of expiration; FVC, forced vital capacity; VAS, visual analog scale.
[a]Data are expressed as median (interquartile range), unless otherwise indicated.

A detailed clinical history was taken and a complete physical examination was performed. The patients were included in the study on the basis of a clinical history of persistent allergic rhinitis and presence of moderate to severe nasal symptoms according to validated criteria [4]. We excluded all those participants who met the following criteria: history of asthma or presence of asthma symptoms (eg, cough, wheezing, dyspnea, and shortness of breath); acute or chronic upper respiratory infections; anatomical nasal disorders (eg, nasal polyps, deviated nasal septum); previous or current smoking (assessed using expired carbon monoxide); previous or current specific immunotherapy; and use of nasal or oral corticosteroids, nasal or oral vasoconstrictors, antileukotrienes, and antihistamines during the previous 4 weeks (ie, if participants confirmed that they were taking medication, they were asked to return after stopping medication for 4 weeks). All patients received treatment on demand with drugs alone.

Persistent allergic rhinitis was diagnosed on the basis of a history of nasal symptoms and positive skin prick test results according to validated criteria [4].

Skin Prick Test

Skin prick tests were performed according to the guidelines of the European Academy of Allergy and Clinical Immunology [15]. The panel consisted of house dust mite (*Dermatophagoides farinae* and *Dermatophagoides pteronyssinus*), cat and dog dander, grass mix, *Compositae* mix, *Parietaria officinalis*, birch, hazel, olive tree, *Alternaria tenuis, Cladosporium*, and *Aspergillus* mix (Stallergènes, Milan, Italy).

VAS Assessment

A VAS was used to assess the subjective sensation of asthma; the score ranged from 0 (severe dyspnea) to 10 (no bothersome symptoms). Patients were asked to position a cross on a line corresponding to their own perception of their respiration. The VAS was performed immediately before and after the bronchodilation test, and the participant was always blinded to the spirometry results.

Spirometry

Spirometry was performed using a computer-assisted spirometer (Pulmolab 435-spiro 235, Morgan, Cardiff, UK) and according to international guidelines [8,9]. The best of 3 readings (1 every 5 min) was recorded.

Bronchodilation Test

The bronchodilation test was performed according to international guidelines using 400 µg of salbutamol. Reversibility was considered as an increase of at least 12% in FEV_1 from baseline [8,9].

Statistical Analysis

Continuous variables were described as the median (interquartile range [IQR]), minimum and maximum, while counts and percentages were used for categorical variables. Descriptive statistics were calculated for prebronchodilation (T0) data and postbronchodilation (T1) data. The differences (Δ) in VAS, FEV_1, FEF_{25-75} and forced vital capacity (FVC) between T0 and T1 were also calculated. The Wilcoxon test for paired data was used to compare data at each timepoint. The association between ΔFEV_1 and ΔVAS was assessed by means of the Spearman rank correlation. For the purpose of this analysis, correlation coefficients were considered as follows: ≥0.8, very strong; 0.6 to 0.79, strong; 0.4 to 0.59, moderate; 0.2 to 0.39, weak; and <0.2, very weak [16]. The nonparametric Wilcoxon test was used to compare changes in VAS between patients with/without a clinically relevant change in nasal airflow. A receiver operating characteristic (ROC) curve analysis was performed to determine a cut point for changes in VAS that optimized sensitivity and specificity and made it possible to identify patients with a clinically relevant change in nasal airflow. In addition, logistic regression was used to build a predictive model for the clinical response to the bronchodilation test. The logistic regression model result was considered correct if a positive/negative response was predicted with a probability higher/lower than 0.5.

Statistical significance was set at $P<.05$. The analysis was performed using Medcalc 9 (Frank Schoonjans, Milan, Italy).

Results

Demographic characteristics and median pretest values of VAS, FEV_1 (% predicted), FVC (% predicted), and FEF_{25-75} (% predicted) are reported in the Table. The median posttest VAS value was 7 (min, 4; max, 10). The median posttest FEV_1 was 102% of predicted (min, 93; max, 113); the median value of posttest FVC was 104% of predicted (min, 85; max, 120); and the median posttest FEF_{25-75} was 95% of predicted (min, 78; max, 115). There was a significant difference ($P<.0001$) between pretest and posttest values of VAS, FEV_1, FVC, and FEF_{25-75} (Figure 1).

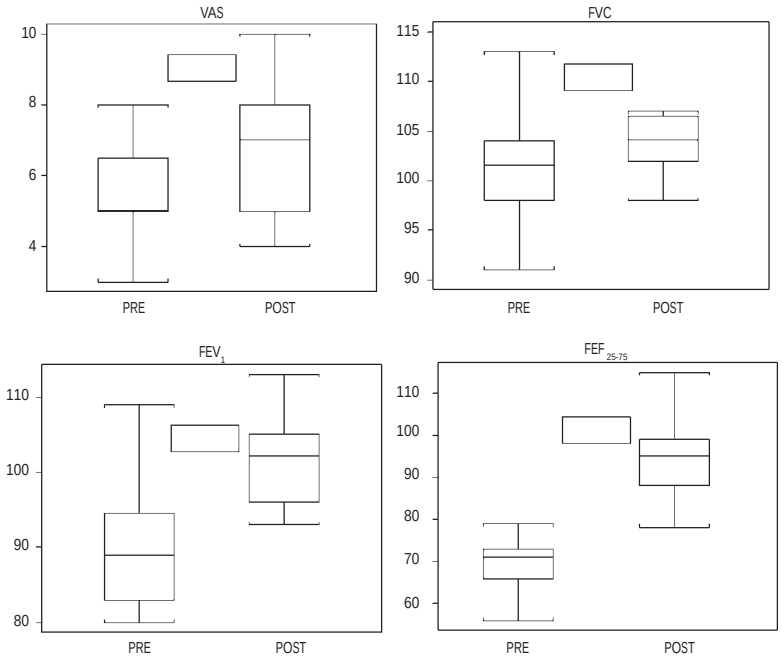

Figure 1. Pretest and posttest VAS, FEV_1, FVC and FEF_{25-75} values. Values are represented as medians (interquartile range). FEF_{25-75}, indicates forced expiratory flow, midexpiratory phase; FEV_1, forced expiratory volume in the first second; FVC, forced vital capacity; VAS indicates visual analog scale.

Sixty patients had a ΔFEV_1 ≥12% of predicted (positive bronchodilation test) and 60 patients had a ΔFEV_1 <12%. FEV_1 increased after testing in all patients: median 11.5% (IQR, 10%-13%; minimum 2%, maximum 15%).

There was a moderate positive correlation between ΔVAS and ΔFEV_1 ($P<.0001$; $r=0.482$) (Figure 2).

There was a significant difference ($P=.0002$) in ΔVAS values between patients with and without a positive response to the bronchodilation test (Figure 3).

ROC analysis did not show any ΔVAS cut point able to discriminate between patients with and without ΔFEV_1 <12% with high efficiency (the optimal cut point was ΔVAS=1, corresponding to a sensitivity, specificity, and efficiency of 55%, 82%, and 68.3%, respectively). Therefore, a predictive multivariate model was applied: the probability of a clinical response was predicted by means of logistic regression based on pretest VAS and age, as well as ΔVAS. Logistic regression showed that age, pretest VAS and ΔVAS were all independently

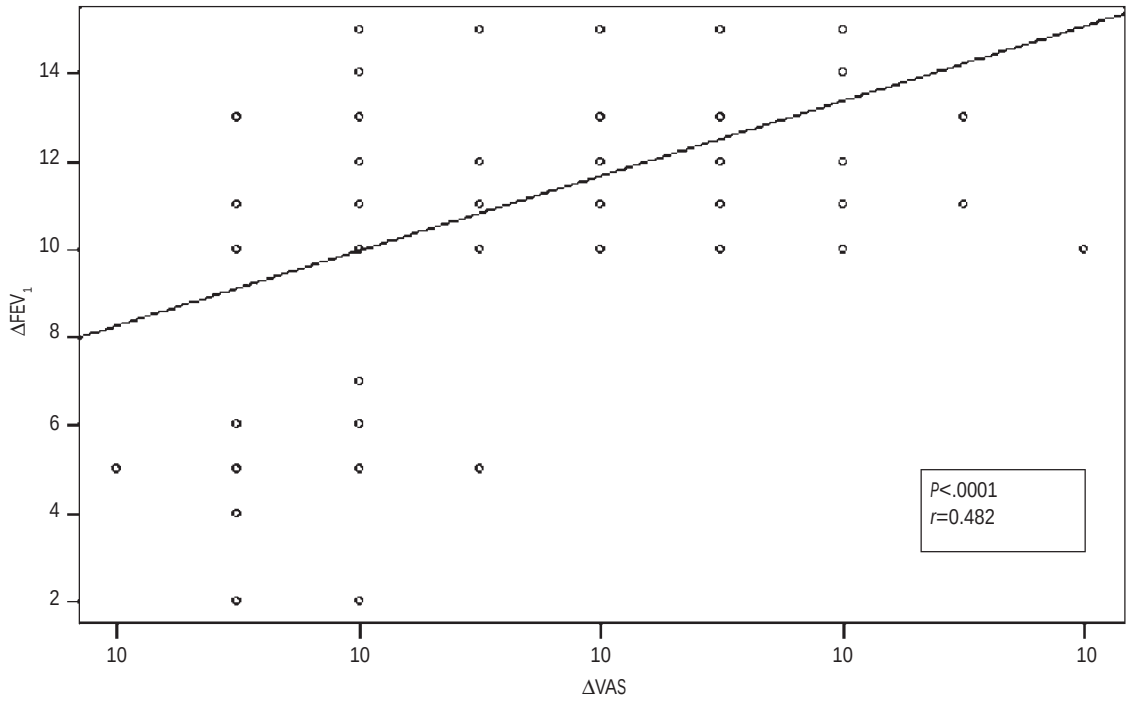

Figure 2. Correlation expressed with the Spearman correlation coefficient (r) and *P* value, between ΔVAS and ΔFEV_1. FEV_1 indicates forced expiratory volume in the first second of expiration; VAS, visual analog scale.

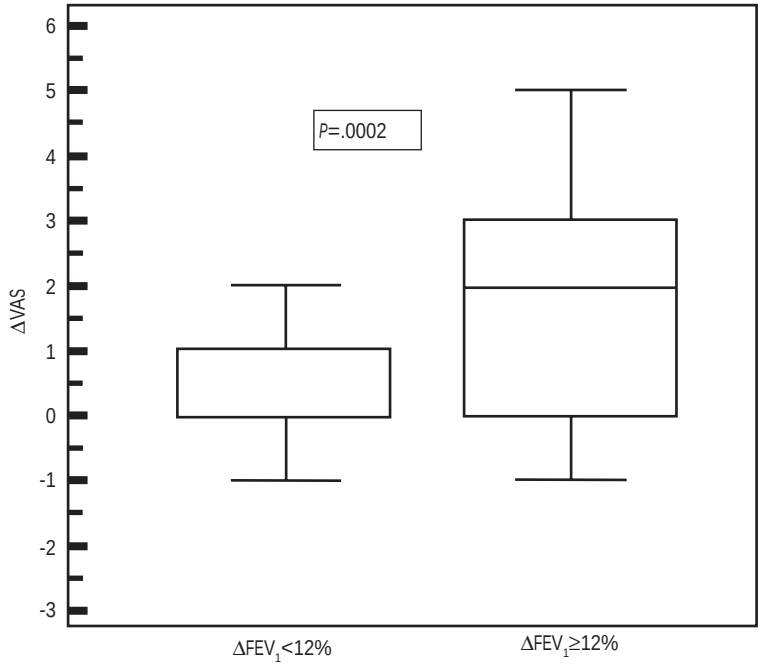

Figure 3. ΔVAS in patients with and without a positive response to the bronchodilation test. Values are represented as medians (lines), quartiles (boxes), and *P* values between the groups.

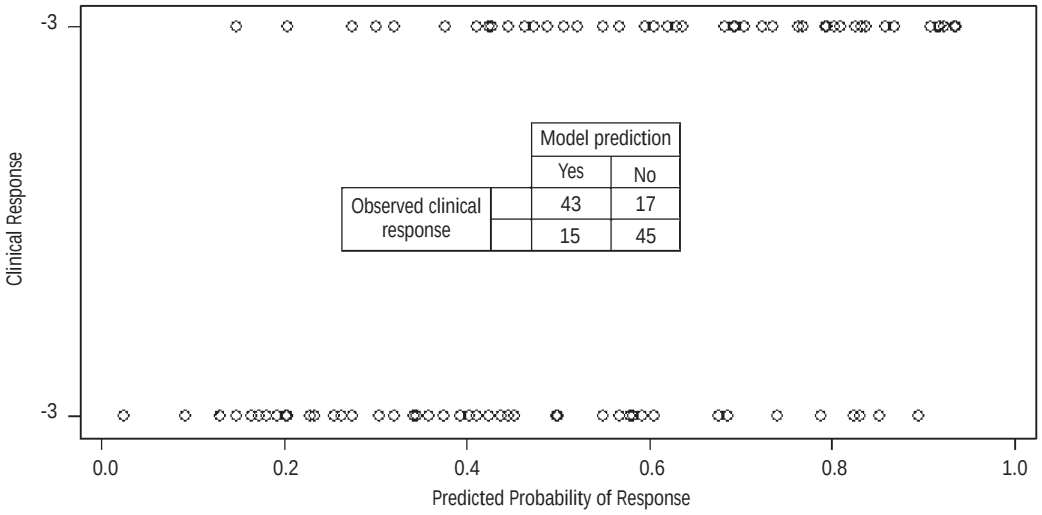

Figure 4. Logistic model for prediction of clinical response (0=negative, 1=positive). The Table inside the figure shows the number of cases correctly and incorrectly classified using a probability of response threshold of 0.5

and significantly correlated with a positive response to bronchodilation (*P*=.002, *P*=.05, *P*=.0004, respectively). The probability of response was given by the formula *p*(response)=exp(c)/[1+exp(c)], where c=5.49+1.81×log (pre-test VAS)+0.54 × ΔVAS-0.39 × age.

The prediction model was considered correct when p(response) was less than 0.5 for a negative responder or ≥0.5 for a positive responder. Figure 4 shows the performance of the model: specificity (true negative rate) was 72% (43/60) and sensitivity (true positive rate) 75% (45/60), with an overall efficiency of 73%.

Discussion

Allergic rhinitis and asthma may be considered a single syndrome involving 2 parts of the respiratory tract, as documented by 2 experimental studies [17,18]. Patients with allergic rhinitis may quite frequently present asthma symptoms, spirometric impairment, or both. Indeed, impaired FEV_1 values may be detected in some patients with allergic rhinitis, even though they perceive nasal symptoms alone [10]. Thus, the link between the upper and lower airways is clear, as is the concept that allergic rhinitis usually precedes overt asthma.

Asthma is characterized by airflow obstruction that is typically reversible, either spontaneously or pharmacologically. This reversibility is a key element in diagnosis. The bronchodilation test should be considered an integral part of spirometry, as it is easily performed and may provide useful information in patients with no overt bronchial airflow obstruction. A recent study showed that as many as two-thirds of patients have a positive response to the bronchodilation test [12]. Therefore, these patients may have an initial bronchial airflow limitation, albeit subclinical. The relevance of this finding has been reinforced by those of a similar study conducted on children [19]. However, although easy to perform, the bronchodilation test requires the availability of a spirometer and trained personnel, so it is rarely used in routine clinical practice for patients with allergic rhinitis and no overt bronchial symptoms. The ARIA document [4] recommends carefully investigating bronchial involvement in patients with allergic rhinitis.

As a VAS is simple to apply and has been validated in allergic rhinitis, the present study was designed to investigate the usefulness of this technique in selecting patients with allergic rhinitis as candidates for spirometry to confirm possible early bronchial impairment.

Our study has several interesting findings. First, we provide evidence that a large percentage (50%) of patients with allergic rhinitis have a positive bronchodilation test result, such as an increase >12% in basal FEV_1 values. Interestingly, all the participants in our study showed a 2%-15% increase in FEV_1 compared with pretest values. Furthermore, all patients had normal baseline FEV_1 values (≥80% of predicted). These findings confirm those of previous studies [12,19], and it seems a reasonable hypothesis that response to the bronchodilation test might be considered further proof of bronchial impairment in allergic rhinitis.

Second, parameters for spirometry and VAS increased significantly after bronchodilation. This reinforces the concept that reversibility is frequently associated with allergic rhinitis.

Third, there is a moderate but significant relationship between ΔFEV_1 and ΔVAS: this finding underlines the possible clinical relevance of the study. Unfortunately, the ROC curve was not informative. However, the predictive model obtained with logistic regression showed that age and VAS, in terms of pretest (logarithmic) value and ΔVAS, correlated significantly with the response to the bronchodilator.

This result contrasts with that of a previous study showing that using VAS alone was significantly predictive for assessing the response to the decongestion test in patients with allergic rhinitis [20]. A possible explanation of this discrepancy might be that the patients evaluated in the present study did not suffer from overt asthma and, consequently, baseline FEV_1 values were obviously normal. On the contrary, patients evaluated using the decongestion test had severe nasal obstruction [20]. Therefore, further studies should be conducted in patients with overt asthma.

In any case, this preliminary study shows that assessment of the bronchodilation test using VAS could prove useful when screening patients with allergic rhinitis, mainly patients with specific characteristics. Our predictive model suggests that the probability of a positive response to the test increases in parallel with the increase in both baseline VAS and ΔVAS, whereas it decreases with age.

In conclusion, this preliminary study provides evidence that patients with moderate to severe persistent allergic rhinitis frequently show reversibility in the bronchodilation test. This event may account for early bronchial involvement, as patients only experienced nasal symptoms. Even though there is no clear cutoff for defining a positive response, a VAS might prove useful for screening of specific patients.

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