Phenotypic and functional activation of alveolar macrophages, T lymphocytes and NK cells in patients with systemic sclerosis and primary Sjögren's syndrome

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Abstract

Objectives—Attempts to differentiate between the pathogenesis of the severe pulmonary manifestations observed in systemic sclerosis (SSc) and the mild form in primary Sjögren's syndrome (pSS) were performed by studying cell populations recovered during bronchoalveolar lavage (BAL).

Methods and results—Two-colour flow cytometric analysis of BAL fluid lymphocytes showed a similar degree of phenotypic activation (DR⁺) of CD4⁺ and CD8⁺ T lymphocyte subsets and CD16⁺ NK cells in patients with SSc (n = 13) and pSS (n = 11) groups and healthy controls (n = 11). Alveolar macrophages expressed the CD14 antigen at significantly increased densities in patients with SSc. Alveolar macrophage activation in SSc was also suggested by increased IL-6 concentrations in neat BAL fluid and increases in macrophage production of TNF α and EGF in vitro. SSc patients also had increased proportions of neutrophils and eosinophils in BAL fluid. No correlations were found between any cellular subsets or cytokine levels in BAL fluid and lung status at the time of lavage in SSc or pSS patients or the subsequent course of the pulmonary function in SSc patients.

Conclusion—It is concluded that the phenotypical activation of alveolar helper/inducer (DR⁺CD4⁺) and suppressor/cytotoxic (DR⁺CD8⁺) T lymphocytes and NK (DR⁺CD16⁺) cells is not a prerequisite for the development of lung fibrosis in SSc or bronchial hyper-responsiveness in pSS. Alveolar macrophage activation may contribute to the development of lung fibrosis in SSc.

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Pulmonary manifestations are common in patients with different forms of connective tissue diseases (CTDs) but the severity of lung involvement may vary considerably depending on the underlying disease.^{1 2} The development of lung fibrosis is one of the life-limiting complications in patients with systemic sclerosis (SSc) and is present in the majority of

patients in necropsy studies.^{3–5} In contrast, patients with primary Sjögren's syndrome (pSS) seldom develop respiratory insufficiency due to lung fibrosis⁶ but frequently suffer from bronchial hyperresponsiveness (BHR) and signs of small airways' disease.^{7–9} The pathogenesis of lung complications in CTDs is generally thought to include inflammatory events or immunological aberrations but these assumptions have not been fully elucidated. Thus the inflammatory mechanisms underlying the increased propensity for lung fibrosis in SSc remain unknown, as does the mechanism behind BHR in pSS. However, the differences in the clinical expression of lung involvement in these CTDs suggest that different inflammatory-immunological principles are present. This study aimed to identify such possible differences in the pathogenetic mechanisms.

Studies of cell suspensions received by bronchoalveolar lavage (BAL) have increased our knowledge of the pathogenesis of different lung processes.^{1 10 11} Although a matter of debate, cells recovered during BAL are considered to represent cell populations present in alveolar tissue.^{10 12 13} With the use of two-colour flow cytometric (FACS) analysis, phenotypically activated and 'functional' subsets of T-lymphocytes, NK cells and macrophages in BAL fluid and peripheral blood from patients with SSc, pSS and healthy controls were characterised. In addition, the levels of certain pro-inflammatory cytokines and growth factors were measured.

Patients and methods

PATIENTS AND CONTROLS

Thirteen patients, four females and nine males (mean age 55 years, range 39–69 years) with diffuse SSc according to the 1980 ARA preliminary diagnosis criteria¹⁴ and eleven female patients (mean age 51 years; range 40–61 years) fulfilling the Copenhagen criteria for pSS¹⁵ were included in this study. Four SSc patients were smokers, while all the pSS patients were non smokers. At the time of the investigation, all patients were admitted to the Rheumatology Section, University Hospital, Uppsala, Sweden.

The control group consisted of eleven non-smoking healthy individuals, seven men and

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four women, mean age 26 years (range 20–31).

LUNG FUNCTION TESTS AND CHEST RADIOGRAPH

All patients had a plain chest radiograph. The lung function tests included measurements of vital capacity (VC), FEV₁, FEF₂₅ and diffusion capacity for carbon monoxide (DLco), measured with the transfer test (single breath test). The values obtained were compared with those of age and sex-matched healthy controls.^{16 17}

Ten patients with pSS were also evaluated with the methacholine inhalation test for bronchial hyper-responsiveness (BHR) as previously described.⁸ The degree of BHR was divided into categories based on the PD20 value: severe (<0.125 mg methacholine), moderate (0.125–1.2), mild (1.3–5.0) and slight (5.1–9.0).

BRONCHOALVEOLAR LAVAGE

Bronchoalveolar lavage (BAL) was performed under local anaesthesia with lidocaine hydrochloride, after premedication with 0.5 mg atropine combined with oral diazepam or with subcutaneous morphine. A wedged fibre-optic bronchoscope (Model BF 1T20D or BF 1T10, Olympus Corp. of America, NY, USA) was used. The bronchoscope was wedged in a segmental bronchus of the middle lobe and three boluses of 50 ml of sterile saline at 37°C were infused. The fluid was gently aspirated immediately after each instillation. The lavage fluid was kept on ice and filtered through a single layer gauze. The cells in the lavage fluid were collected by centrifugation at 400 g for 15 minutes and were thereafter resuspended to a concentration of 10⁶ cells/ml excluding epithelial cells. The total number of cells in the lavage fluid was counted in a Bürker chamber. The cell differential was determined by using cytocentrifuge preparations and May-Grünwald-Giemsa staining. Lymphocytes were expressed as percentage of 200 cells (except epithelial cells) counted. Cell-free BAL fluid was freeze-stored at –70°C pending later analysis of soluble factors (see below).

CULTURE OF BAL CELLS

BAL alveolar macrophages were suspended in RPMI 1640 medium supplemented with 10% fetal calf serum (Flow Laboratories, Glasgow, Scotland) and incubated at a concentration of 1 × 10⁶/ml in 2 ml plastic wells (Nunc, Denmark) for two hours at 37°C in a humidified 5% CO₂ atmosphere. Non-adherent cells were removed and adherent macrophages (1 × 10⁶/ml) were further cultured for 20 hours, after which supernatants were analysed for the presence of various cytokines (see below).

ANTIBODIES AND FACS ANALYSIS

Mononuclear cells were separated from heparinised blood by routine Ficoll-Hypaque

(Pharmacia, Uppsala, Sweden) density centrifugation. The cells were washed, suspended (10⁶/50 µl) in phosphate-buffered saline supplemented with 2% fetal calf serum (Flow Lab) and 0.1% sodium azide and incubated for 15 minutes at room temperature with combinations of optimally diluted fluorescein-isothiocyanate-labelled monoclonal antibodies (Becton Dickinson, Mountain View, CA) raised against lymphocyte subsets or activation antigens (table 1). Irrelevant negative control antibodies of the same Ig isotypes (Simultest, Becton Dickinson) were used. To facilitate lymphocyte gating, samples were also stained with anti-CD45 (pan-leukocyte) plus anti-CD14 (monocyte) antibodies (Leukogate, Becton Dickinson). After washing, cells were suspended in the same medium supplemented with 1% paraformaldehyde (BDH, Poole, UK). Fluorescent cells were analysed in a FACStar (Becton Dickinson) analyser/sorter equipped with a 5W argon laser emitting at 488 nm and running at 0.2W. A total of 10⁴ lymphoid cells were gated and red (phycoerythrin) fluorescence was collected through a 585/42 nm filter and green (fluorescein isothiocyanate) fluorescence through a 530 nm filter. For enumeration of monocytes, scatter gates were set on lymphocytes and monocytes. Data were processed with a Hewlett-Packard 217 computer (H-P, Fort Collins, CO) with Consort 30 software (Becton Dickinson).

CYTOKINE ANALYSIS

Neat BAL fluid and supernatants of BAL macrophage cultures were analysed for the presence of the pro-inflammatory cytokines IL-1 (minimum detectable concentration (mdc): 5 pg/ml), IL-6 (mdc: 3.5 pg/ml) and TNFα (mdc: 5 pg/ml) using commercial ELISA kits (IRE Medgenix, Fleurus, Belgium). The levels of the growth factors EGF (mdc: 0.2 pg/ml) and PDGF (mdc: 8.4 pg/ml) were also determined using commercial ELISAs (British Biotechnology Products, Abingdon, UK).

STATISTICAL ANALYSIS

Values are given as means (SEM) (range). Non-parametric tests (Mann-Whitney U test and Spearman Rank Correlation coefficient) were used to analyse the data. A p-value of <0.05 was considered significant when comparing patient groups but a p-value of <0.01 was required, when comparing lymphocyte subsets and clinical or spirometric findings.

Results

CLINICAL FINDINGS

Patients with SSc had a mean disease duration of five years (range 0.5–12 years). All patients had various degrees of exertional dyspnoea. Fibrotic changes were visible in eight of 13 patients (63%) on chest radiograph. Pulmonary function tests demonstrated that the mean DLco for the SSc group was 51% of

the predicted value (range 5–81); 12 of 13 patients had an impaired DLco. The mean VC was 78% of the predicted value (range 49–104); six of the 13 SSc patients had a reduced VC. Five (38%) of the SSc patients suffered from dry eyes and mouth and had pathological schirmer-I and salivation tests suggesting secondary SS. Four of 11 SSc patients demonstrated a significant progress in their pulmonary manifestations when they were followed up, on average 36 months (range 12–66) after the BAL evaluation.

Patients with pSS had a mean disease duration of 10 years (range 2–17 years). Seven patients (64%) reported symptoms of xerotracheitis sicca and only one patient had history of exertional dyspnoea. Only one pSS patient had minimal diffuse interstitial densities in both lungs on chest radiograph. Their mean DLco was 81% of the predicted value (range 63–111); five patients with pSS had a slightly impaired DLco. The mean VC was 93% of the predicted value (range 65–125); only two patients had a reduced VC. The mean FEF₂₅ was 74% of the predicted value (range 27–200); three patients had reduced FEF₂₅, that is, <50%, and six patients had FEF₂₅ <80% of predicted. Four of 10 tested pSS patients had mild or moderate BHR and two patients had slight BHR.

No patient was on corticosteroids or any disease modifying anti-rheumatic drugs at the time of the respiratory evaluation.

CELL RECOVERY AND DIFFERENTIAL COUNT IN BAL FLUID

No significant differences were observed in the amount of the re-covered BAL-fluid in the three investigated groups. The total mean

(SEM) cell recovery in the lavage fluid was significantly increased in patients with SSc [$3.2 (0.5) \times 10^5$ cells/ml; range 1.3–6.9] compared with controls ($p < 0.01$). No difference was observed between patients with pSS [$2.8 (0.8) \times 10^5$ cells/ml; range 0.6–8.7] and controls [$1.2 (0.3) \times 10^5$ cells/ml; range 0.2–2.8]. Patients with SSc had increased numbers of neutrophils and eosinophils in BAL fluid compared with both pSS patients ($p < 0.05$; $p < 0.01$) and controls ($p < 0.01$; $p < 0.001$). No difference was observed between pSS patients and healthy controls regarding total cells or cell differentials (fig 1, table 1). No correlation was observed between any of the differential cell types in BAL fluid and the spirometric findings in either patient group or the degree of BHR.

T-CELL SUBSETS IN BAL FLUID AND PERIPHERAL BLOOD

In all individuals studied, a significant ($p < 0.0001$) activation of helper/inducer T cells (T_h) (DR^+ out of $CD4^+$) and suppressor/cytotoxic T cells (T_{SCX}) (DR^+ out of $CD8^+$) and a decrease in naive, unprimed helper T cells ($CD45RA^+$ out of $CD4^+$) was observed in BAL fluid when compared with peripheral blood (fig 2). No significant differences were observed between the three groups when the absolute numbers of T cell subsets in BAL fluid were compared (table 2) and no correlation was found between these and the spirometric/chest radiographic findings.

The SSc patients had a significantly higher percentage of activated T_h cells in peripheral blood compared with pSS patients ($p < 0.01$) and controls ($p < 0.001$) and they also had a significantly increased percentage of activated T_{SCX} cells compared with the controls ($p < 0.01$) (fig 2).

Table 1 Monoclonal antibodies, their specificities and references

MAbs*	CD*	Cell population defined	Reference
Leu 3	4	Helper/inducer T cells (T_h)	18
Leu 2	8	Suppressor/cytotoxic T cells (T_{SCX})	19, 20
HLA-DR*Leu 3	ns + 4	Activated $CD4^+$ cells	18, 21, 22
HLA-DR*Leu 2	ns + 8	Activated $CD8^+$ cells	18, 21, 22
Leu 18/Leu 3	45RA	Naive, unprimed $CD4^+$ T cells	23
Leu 11	16	NK-like cells	24
HLA-DR* Leu 11	ns + 16	Activated $CD16^+$ cells	25
Leu M3	14	Monocytes	26

*MAbs = monoclonal antibodies; CD = cluster of differentiation; ns = CD number not specified.

†associated with autoantibody production.

Figure 1 Absolute numbers of lymphocytes, neutrophils and eosinophils in BAL fluid of patients with primary Sjögren's syndrome (pSS) and systemic sclerosis (SSc). Shaded areas indicate mean and 95% confidence interval for healthy controls. Significant difference with U-test: SSc v pSS: * = $p < 0.05$ and ** = $p < 0.01$. SSc v controls: †† = $p < 0.01$ and ††† = $p < 0.001$.

NK CELLS IN BAL FLUID AND PERIPHERAL BLOOD

All individuals had a significantly increased phenotypic activation of NK cells (DR^+ out of $CD16^+$) in BAL fluid compared with peripheral blood ($p < 0.001$). The BAL fluid of patients with SSc also contained significantly higher percentages of activated NK cells compared with patients with pSS ($p < 0.05$) (fig 2). When the absolute numbers of NK cells ($CD16^+$) and activated NK cells were compared, no significant differences were observed between the groups (table 2) and no correlations were observed between these and the spirometric/chest radiographic findings.

Patients with pSS had a decreased mean (SEM) percentage of NK cells in peripheral blood [$5.5 (1.0)$] compared with controls [$11.8 (2.3)$; $p < 0.05$].

MONOCYTES IN BAL FLUID AND PERIPHERAL BLOOD

Patients with pSS and SSc as well as healthy controls had similar percentages of monocytes/macrophages ($CD14^+$) in BAL fluid and

peripheral blood (table 3). On the other hand, the BAL macrophages of patients with SSc expressed the CD14 antigen molecule at a

significantly higher density than those of controls ($p < 0.05$) (table 2). No correlations were observed between the percentage of BAL monocytes/macrophage or the intensity of expression of the CD14 antigen and the spirometric/chest radiographic findings.

Figure 2 Activated lymphocyte subsets in BAL fluid and peripheral blood (PBL) from 11 patients with primary Sjögren's syndrome (pSS), 13 patients with systemic sclerosis (SSc) and 11 healthy controls. Results are expressed as mean percentage (SEM). Significant difference with U-test: SSc v controls: †† = $p < 0.01$ and ††† = $p < 0.001$. SSc v pSS: * = $p < 0.05$ and ** = $p < 0.01$.

Table 2 Absolute number of lymphocyte subsets in BAL fluid from thirteen patients with systemic sclerosis (SSc (n)), eleven primary Sjögren's syndrome (pSS (n)) and eleven healthy non-smokers (controls (n)). Results are expressed as means (SEM)

Lymphocyte subsets	Cells/ml recovered in BAL		
	SSc	pSS	Controls
Helper/inducer T-cells (CD4 ⁺)	6067 (1969)	7250 (2715)	5537 (2288)
Activated CD4 ⁺ T-cells (DR + CD4 ⁺)	2062 (656)	2276 (951)	1940 (910)
Suppressor/cytotoxic T-cells (CD8 ⁺)	11881 (6412)	6182 (1762)	4530 (1821)
Activated CD8 ⁺ T-cells (DR + CD8 ⁺)	3924 (1925)	1623 (571)	2323 (1505)
Naive helper T-cells (CD45RA + CD4 ⁺)	418 (193)	98 (26)	143 (55)
NK-cells (CD16 ⁺)	662 (146)	419 (230)	307 (145)
Activated CD16 ⁺ NK-cells (DR + CD16 ⁺)	334 (103)	266 (100)	279 (173)

Table 3 Monocytes/macrophages in BAL fluid and peripheral blood (PBL) from 11 patients with primary Sjögren's syndrome (pSS), 13 patients with systemic sclerosis (SSc) and 13 healthy non-smokers

	Monocytes/Macrophages (CD14 ⁺) mean % (SEM)	Relative CD14 intensity (linear channel no)
PBL		
SSc	7.5 (0.8)	246.8 (16.9)
pSS	7.1 (0.6)	233.2 (34.8)
Controls	8.5 (1.5)	213.0 (14.8)
BAL		
SSc	42.1 (7.7)	840.8 (281.2)†
pSS	44.8 (7.9)	396.0 (118.7)
Controls	56.2 (5.8)	306.0 (22.0)

Significant difference with Mann-Whitney U test: SSc vs controls: † = $p < 0.05$.

Table 4 Concentrations of IL-1, IL-6, TNF α , EGF and PDGF in neat bronchoalveolar lavage fluid (BAL) and in supernatants of BAL macrophage cultures of patients with primary Sjögren's syndrome (pSS), systemic sclerosis (SSc) and healthy controls. Results are presented as means (SEM) (n).

		pSS	SSc	Controls
IL-1	BAL (pg/ml)	108 (4) (n = 11)	99 (4) (n = 11)	105 (3) (n = 8)
	Mo-cult (pg/ml)	159 (20) (n = 3)	2090 (1479) (n = 2)	2474 (120) (n = 2)
IL-6	BAL (pg/ml)	4.1 (1.9) (n = 11)	18.4 (10.5)†† (n = 11)	0.9 (0.9) (n = 11)
	Mo-cult (pg/ml)	2651 (1550) (n = 5)	5173 (1886) (n = 5)	8602 (38) (n = 2)
TNF α	BAL (pg/ml)	56 (4) (n = 11)	55 (4) (n = 11)	53 (4) (n = 8)
	Mo-cult (μg/ml)	24.6 (19.2) (n = 11)	87.1 (30.7)* (n = 6)	26.0 (14.2) (n = 4)
EGF#	BAL (pg/ml)	3.2 (0.5) (n = 11)	4.3 (0.5) (n = 10)	4.4 (3.4) (n = 12)
	Mo-cult (μg/ml)	not detected (n = 4)	1.4 (0.5) (n = 11)	not detected (n = 3)
PDGF#	BAL (pg/ml)	not detected (n = 11)	not detected (n = 10)	not detected (n = 12)
	Mo-cult (μg/ml)	not detected (n = 4)	not detected (n = 4)	not detected (n = 4)
Albumin	BAL (mg/L)	41.6 (17.2) (n = 11)	87.9 (38.1)** (n = 10)	34.8 (3.9) (n = 12)

Significant difference with Mann-Whitney U test: pSS vs SSc: * = $p < 0.05$, ** = $p < 0.01$; SSc vs controls: †† = $p < 0.01$. #minimal measurable concentration 0.2 pg/ml for EGF and 31.3 pg/ml for PDGF.

CYTOKINES IN BAL

The pro-inflammatory cytokines IL-1, IL-6 and TNF α as well as the growth factors EGF and PDGF were measured in neat BAL fluid and the supernatants of macrophage cultures (table 4). Increased concentrations of IL-6 ($p < 0.01$ vs controls) were found in patients with SSc. However, when indexed to BAL fluid albumin, this difference disappeared. Significant differences arise between patients with SSc and pSS as regards the concentrations of IL-1 in neat BAL fluid ($p < 0.001$).

The BAL macrophages synthesis of TNF α but not IL-6, was also increased in vitro in patients with SSc compared with pSS ($p < 0.05$). EGF was similar in neat BAL fluid in all three group, but was only detected in the macrophage cultures taken from patients with SSc. PDGF was not detectable either in the neat BAL fluid or the supernatants of BAL macrophage cultures in any of the three groups. Abnormal concentrations of measured cytokines were not related to spirometric/chest radiographic findings.

No correlation was found between any cellular subsets or cytokine levels in neat or cultured BAL fluid of the SSc patients and the subsequent course of their pulmonary function.

Discussion

The connective tissue diseases, systemic sclerosis (SSc) and primary Sjögren's syndrome (pSS), are both characterised by immunological abnormalities, including the presence of auto-antibodies and infiltration of activated T-cells in affected organs. However, the pronounced propensity of tissue fibrosis in SSc is lacking in pSS, indicating differences in their respective pathogenesis. Progressive pulmonary fibrosis is a major manifestation of SSc³⁻⁵ but quite rare in pSS.^{7,8} However, patients with pSS frequently suffer from small airways' disease and BHR.^{8,9} The present study of BAL fluid aimed to identify possible differences in

the pathogenetic mechanisms involved in the pulmonary processes involved in these two CTDs. Comparison of the effector cells recovered by BAL to those present in open lung biopsies has shown that the cell population recovered by lavage accurately reflect the population of effector cells present in the alveolar structure.¹⁰ The cells involved in the parenchymal damage of systemic sclerosis are likely to originate from the alveoli. In contrast, BHR may be due to a bronchial inflammation suggesting that the most active cells are located in the bronchi themselves. However, in the presence of bronchial inflammation, it is impossible to tell whether the effector cells are airway or alveolar derived.

The major difference was the phenotypic activation of macrophages recovered from the BAL fluid of patients with SSc. Thus FACS analysis revealed a three fold increase in the expression of the CD14 molecules on alveolar macrophages in SSc. The expression of CD14, a selective marker for monocytes/macrophages and representing the receptor for bacterial lipopolysaccharides,²⁷ increases in the in vitro and in vivo activation of monocytoïd cells.²⁸⁻²⁹ The cytokines IL-1, IL-6 and TNF- α are produced by several types of nucleated cells but activated monocytes/macrophages are major sources. Therefore a macrophage activation in the lung of SSc patients was also suggested by the finding of abnormally elevated IL-6 levels in their neat BAL fluid and increased production of TNF- α by their cultured alveolar macrophages. Other studies have also demonstrated signs of alveolar macrophage activation in SSc. Silver *et al* reported that alveolar macrophages in SSc produce fibronectin in vitro³⁰ and Degucchi found that these cells have an increased in vitro production of transforming growth factor- β ,³¹ a potent fibroblast mitogen. In our study, the growth factor EGF was only synthesised by SSc alveolar macrophages, while PDGF, another growth factor produced by activated macrophages and previously suggested to contribute to fibrotic lesions in SSc,³² was not detectable in neat BAL fluid or macrophage culture supernatants from our SSc or pSS patients. However, the relevance of the increased activation of BAL macrophages to the clinical expression can be questioned since these cells were not correlated to the lung status at the time of the lavage or to the subsequent course of pulmonary function.

Two-colour FACS analysis was also used to quantify the phenotypic activation of CD4⁺ T helper cells, CD8⁺ T cytotoxic/suppressor cells and CD16⁺ NK cells in BAL fluid and peripheral blood. The naive, unprimed subset of T helper cells (CD45RA⁺CD4⁺) was also determined. A general feature emerged that was similar in both patients and healthy subjects—a profound local immune activation in the lower respiratory tract. Thus compared with circulating cells, BAL fluid T subset cells and NK cells expressed high levels of the activation marker HLA-DR,²² and the proportion of naive T helper cells was close to

zero, indicating functional CD4⁺ T cell activation.²³ Generally, however, no disease-specific or severity-related cell patterns were observed. Earlier studies have reported a marginally increased proportion of CD4⁺ and CD8⁺ T cells in the BAL fluid of patients with SSc³³ and normal, relative but increased absolute numbers of CD4⁺ and CD8⁺ T cells in patients with pSS.³⁴ Subclinical BAL lymphocytosis has also been reported in pSS.³⁵

Our results of increased activated T_H and T_{SCX} cells in the peripheral blood of patients with SSc agree with previous reports³⁶⁻³⁷ and our study, like several other previous studies, fails to demonstrate significant abnormalities in the distribution of circulating lymphocyte subsets in patients with pSS.³⁸⁻³⁹

Patients with pSS have only a minor propensity for pulmonary fibrosis.⁶ However, they frequently suffer from BHR and spirometrically small airways' disease. The mechanism behind the BHR in pSS is unknown but may be related to an inflammation in the lower respiratory tract. In other conditions, BHR has been suggested to be the result of an activation of various cell types; alveolar macrophages, mast cells, eosinophils and neutrophils.⁴⁰ Furthermore, the release of cytokines may alter nerve and smooth muscle function, resulting in bronchial constriction.⁴¹ However, we did not find any correlation between the degree of BHR and the various cell subsets or cytokines analysed in BAL fluid of our pSS patients. In accordance with previous observations⁴²⁻⁴⁴ we found an increased numbers of neutrophils and eosinophils in the BAL fluid of patients with SSc.

In conclusion, the present study demonstrates local lymphocyte activation in the lower respiratory tract to a similar degree both in health and CTDs, supporting the view that local lymphocyte activation at the mucosal borders of the lungs reflects immune surveillance, rather than a pathogenetic process. On the contrary, we demonstrated an abnormally increased phenotypic and functional activation of alveolar macrophages in patients with SSc. This activation of alveolar macrophages may contribute to the endothelial damage and pulmonary fibrosis associated with this disease by means of a release of proinflammatory and mitogenic cytokines.

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