

---

---

# Sonographic assessment of interstitial lung disease in patients with rheumatoid arthritis, systemic sclerosis and systemic lupus erythematosus

---

F. Moazedi-Fuerst<sup>1</sup>, S. Kielhauser<sup>1</sup>, K. Brickmann<sup>1</sup>, N. Tripolt<sup>1</sup>, M. Meilinger<sup>2</sup>,  
A. Lutfi<sup>3</sup>, W. Graninger<sup>1</sup>

---

---

<sup>1</sup>Division of Rheumatology;

<sup>2</sup>Division of Pulmonology, and

<sup>3</sup>Department of Radiology, Medical University of Graz, Graz, Austria.

Florentine C. Moazedi-Fuerst, MD

Sonja Kielhauser, MD

Kerstin Brickmann, MD

Norbert Tripolt, MSc

Michael Meilinger, MD

Andre Lutfi, MD

Winfried Graninger, MD

Please address correspondence to:

Dr Florentine C. Moazedi-Fuerst,

Division of Rheumatology

and Immunology,

Medical University Graz,

Auenbruggerplatz 15,

8036 Graz, Austria.

E-mail: florentine.fuerst@medunigraz.at

Received on March 21, 2014; accepted in

revised form on December 1, 2014.

*Clin Exp Rheumatol* 2015; 33 (Suppl. 91):  
S87-S91.

© Copyright CLINICAL AND

EXPERIMENTAL RHEUMATOLOGY 2015.

**Key words:** lung ultrasound, systemic lupus erythematosus, systemic sclerosis, rheumatoid arthritis

## ABSTRACT

**Objective.** The usefulness of transthoracic ultrasound in the evaluation of lung diseases has been highlighted in the past decades. The aim of our study is to determine the diagnostic value of lung ultrasound in the detection of interstitial pulmonary

fibrosis in patients with a rheumatic disease. Furthermore, we studied the possible correlation between the underlying disease and the frequency of pathological ultrasound findings.

**Methods.** A sample of 45 consecutive patients with RA (n=25), SSc (n=14) and SLE (n=6) and 40 healthy volunteers were enrolled into the study. Every study patient underwent both, lung sonography and HRCT. The following ultrasound findings were documented in each study patient: B- lines, subpleural nodes and irregularities of the pleura. HRCT was analysed by an experienced radiologist blind to sonography findings.

**Results.** Twenty-eight percent of the RA cohort, 64% of the SSc patients and four out of 6 SLE patients showed ILD on HRCT. Pathological ultrasound patterns were significant more frequent in the ILD group than in the non-ILD group (comet tail artifacts/B-pattern: 100% vs. 12%,  $p<0.001$ ; subpleural nodes: 55 % vs. 17%,  $p=0.006$ ; thickenings of the pleural line: 95% vs. 12.5%,  $p<0.001$ ).

Subpleural nodes were present in 100% of the RA patients vs. 22% the SSc patients ( $p=0.003$ ) and 50% of the SLE patients ( $p=0.049$ ) with ILD. An irregular pleural line  $>3$  mm was documented in 100% of SSC and SLE patients with ILD, vs. 86% of ILD patients suffering from RA ( $p=ns$ ).

**Conclusion.** Transthoracic ultrasound of the lung might be a sensitive non-

invasive tool to observe early stage interstitial lung disease in rheumatic diseases.

## Introduction

Interstitial lung disease (ILD) is a frequent manifestation of systemic autoimmune diseases (1). In diffuse and limited systemic sclerosis (SSc), lung involvement is the leading cause of death (2). Mortality due to ILD is increased in patients with rheumatoid arthritis (RA) and systemic lupus erythematosus (SLE) thus necessitating an increased awareness towards this complication (3, 4).

High resolution computed tomography (HRCT) of the lung is the gold standard for the non-invasive diagnosis of ILD. This technique is more sensitive than conventional radiography and it corresponds well with the diffusing capacity of the lung (DLCO) (5, 6).

Sonography is an easily available and cheap diagnostic tool without exposure to radiation. In the past decade, the usefulness of transthoracic ultrasound in the assessment of lung diseases has evolved (7-12). Some recent studies evaluated the diagnostic value of transthoracic ultrasound in patients with diffuse parenchyma lung disease (DPLD) (7-10). Sonographic signs like tissue B-lines, irregularities of the pleura or the absence of lung sliding might be a suitable screening tool for lung involvement (13, 14). Our group published the importance of lung ultrasound in the work up of patients with scleroderma and rheumatoid arthritis (11, 15).

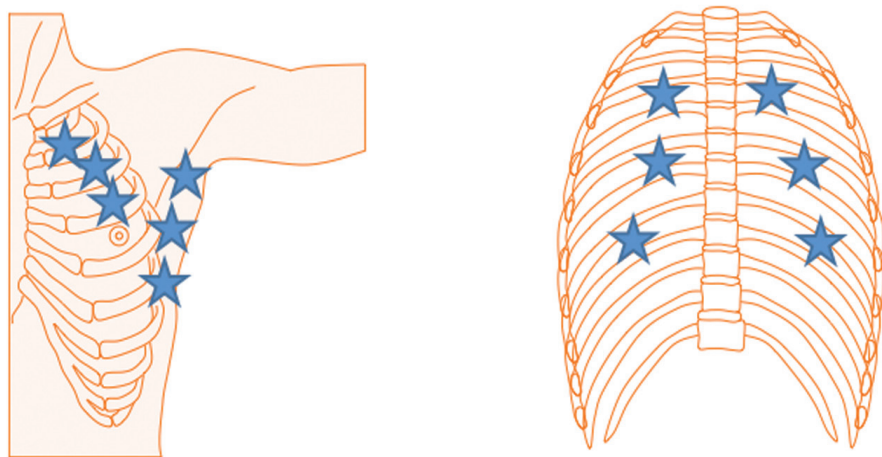
The aim of the current study was to determine the diagnostic performance of lung ultrasonography in the diagnosis of ILD in patients with RA, SLE and SSc. Furthermore, we studied for the first time, the possibility of a correla-

Funding: the study was funded by the Land Steiermark Fond.

Competing interests: none declared.

**Table I.** Demographic data.

Characteristic	Patients	Healthy volunteers
Age	54 (28-74)	49 (26-71)
Sex (%)		
male	15	11
female	85	39
Mean duration since diagnosis of rheumatic disease (years)	8 (1-35)	
Treatment (%)		
DMARD	31	
Biologics	56	
Cyclophosphamide	5	
Corticosteroids	15	



**Fig. 1.** Schematic drawing of the left anterior thoracic wall, the left lateral wall and the rib cage. Points of measurements are marked (★). In total 18 points are evaluated, 9 points on the left and right side of the thoracic wall (anterior apical, anterior medial and anterior basal/ lateral apical, lateral medial and lateral posterior/posterior apical, posterior medial and posterior basal).

tion between the underlying disease and the occurrence of different lung ultrasound findings.

**Material and methods**

*Study design and population*

The study was approved by the local ethics committee.

Forty-five consecutive patients without acute pulmonary complaints attending the rheumatology outpatient clinic of our university hospital were subjected to lung sonography and HRCT after obtaining written consent. They fulfilled the American College of Rheumatology (ACR) criteria for RA (n=25), SSC (n=14) or SLE (n=6). The clinical characteristics of the patients are described in Table I (age, sex, duration of disease, previous immunosuppressive treatment, previous or current corticosteroids). Pulmonary function tests revealed normal FVC and DLCO in all groups except SSC. A sample of 40 healthy volunteers was examined (Table I)

A HRCT of RA, SSC and SLE patient was analysed by an experienced radiologist (L.A.). The radiological presence of signs of interstitial lung disease was assessed according to Remy-Jardin *et al.* (16).

**RECHTE LUNGE:**

Antero-apikal: <input type="checkbox"/> neg. Lungsliding <input type="checkbox"/> B-Lines <input type="checkbox"/> Fragm.Pleura <input type="checkbox"/> Knötchen Pleuralinie: _____mm
Antero-medial: <input type="checkbox"/> neg. Lungsliding <input type="checkbox"/> B-Lines <input type="checkbox"/> Fragm.Pleura <input type="checkbox"/> Knötchen Pleuralinie: _____mm
Antero-basal: <input type="checkbox"/> neg. Lungsliding <input type="checkbox"/> B-Lines <input type="checkbox"/> Fragm.Pleura <input type="checkbox"/> Knötchen Pleuralinie: _____mm
Latero-apikal: <input type="checkbox"/> neg. Lungsliding <input type="checkbox"/> B-Lines <input type="checkbox"/> Fragm.Pleura <input type="checkbox"/> Knötchen Pleuralinie: _____mm
Latero-medial: <input type="checkbox"/> neg. Lungsliding <input type="checkbox"/> B-Lines <input type="checkbox"/> Fragm.Pleura <input type="checkbox"/> Knötchen Pleuralinie: _____mm
Latero-basal: <input type="checkbox"/> neg. Lungsliding <input type="checkbox"/> B-Lines <input type="checkbox"/> Fragm.Pleura <input type="checkbox"/> Knötchen Pleuralinie: _____mm
Postero-apikal: <input type="checkbox"/> neg. Lungsliding <input type="checkbox"/> B-Lines <input type="checkbox"/> Fragm.Pleura <input type="checkbox"/> Knötchen Pleuralinie: _____mm
Postero-medial: <input type="checkbox"/> neg. Lungsliding <input type="checkbox"/> B-Lines <input type="checkbox"/> Fragm.Pleura <input type="checkbox"/> Knötchen Pleuralinie: _____mm
Postero-basal: <input type="checkbox"/> neg. Lungsliding <input type="checkbox"/> B-Lines <input type="checkbox"/> Fragm.Pleura <input type="checkbox"/> Knötchen Pleuralinie: _____mm

**LINKE LUNGE:**

Antero-apikal: <input type="checkbox"/> neg. Lungsliding <input type="checkbox"/> B-Lines <input type="checkbox"/> Fragm.Pleura <input type="checkbox"/> Knötchen Pleuralinie: _____mm
Antero-medial: <input type="checkbox"/> neg. Lungsliding <input type="checkbox"/> B-Lines <input type="checkbox"/> Fragm.Pleura <input type="checkbox"/> Knötchen Pleuralinie: _____mm
Antero-basal: <input type="checkbox"/> neg. Lungsliding <input type="checkbox"/> B-Lines <input type="checkbox"/> Fragm.Pleura <input type="checkbox"/> Knötchen Pleuralinie: _____mm
Latero-apikal: <input type="checkbox"/> neg. Lungsliding <input type="checkbox"/> B-Lines <input type="checkbox"/> Fragm.Pleura <input type="checkbox"/> Knötchen Pleuralinie: _____mm
Latero-medial: <input type="checkbox"/> neg. Lungsliding <input type="checkbox"/> B-Lines <input type="checkbox"/> Fragm.Pleura <input type="checkbox"/> Knötchen Pleuralinie: _____mm
Latero-basal: <input type="checkbox"/> neg. Lungsliding <input type="checkbox"/> B-Lines <input type="checkbox"/> Fragm.Pleura <input type="checkbox"/> Knötchen Pleuralinie: _____mm
Postero-apikal: <input type="checkbox"/> neg. Lungsliding <input type="checkbox"/> B-Lines <input type="checkbox"/> Fragm.Pleura <input type="checkbox"/> Knötchen Pleuralinie: _____mm
Postero-medial: <input type="checkbox"/> neg. Lungsliding <input type="checkbox"/> B-Lines <input type="checkbox"/> Fragm.Pleura <input type="checkbox"/> Knötchen Pleuralinie: _____mm
Postero-basal: <input type="checkbox"/> neg. Lungsliding <input type="checkbox"/> B-Lines <input type="checkbox"/> Fragm.Pleura <input type="checkbox"/> Knötchen Pleuralinie: _____mm

**Fig. 2.** Case report file used to document the findings in each patient for the right and the left lung. Negative lung sliding, b-lines, fragmented pleura, noduli and the pleura thickness are documented.

### Ultrasound methodology

Transthoracic sonography with a convex 3, 5 MHz transducer (LOQ 7, GE) and a linear probe (LOQ7, GE), to observe the pleura, was performed by two experienced investigators (F. M.-F. K.M.) in lung ultrasound, blind to HRCT results.

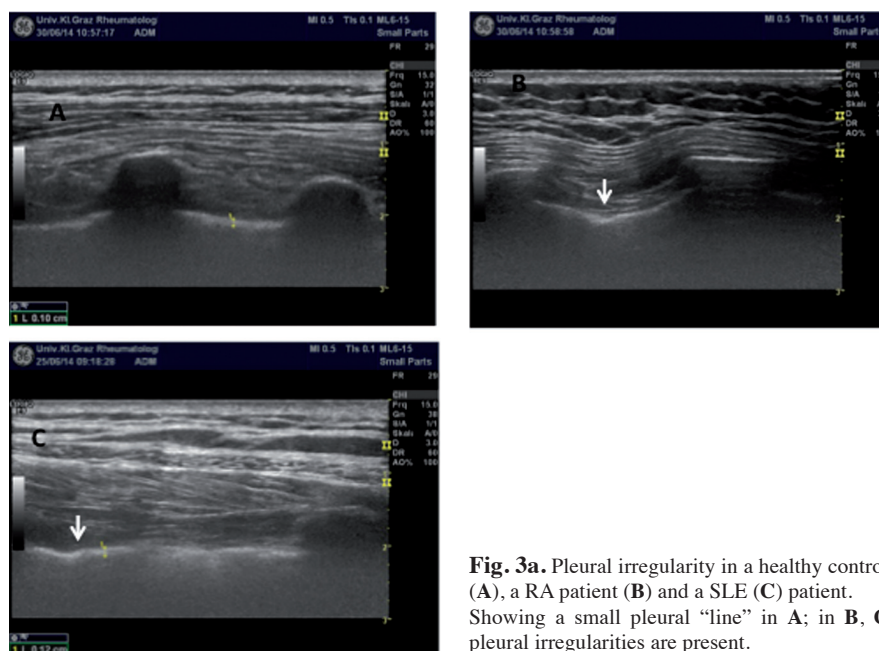
The thoracic wall was divided into 18 regions (Fig. 1) that were scanned systematically in each patient (11, 15). The anterior pleural surface was investigated in a supine position while the lateral and posterior surface was scanned in a sitting position. Scans were performed in a longitudinal or intercostal plane. The following sonographic features were documented in each patient using a special case report form (Fig. 2).

**Artifacts:** two different types of artifacts arising from the pleural line were distinguished.

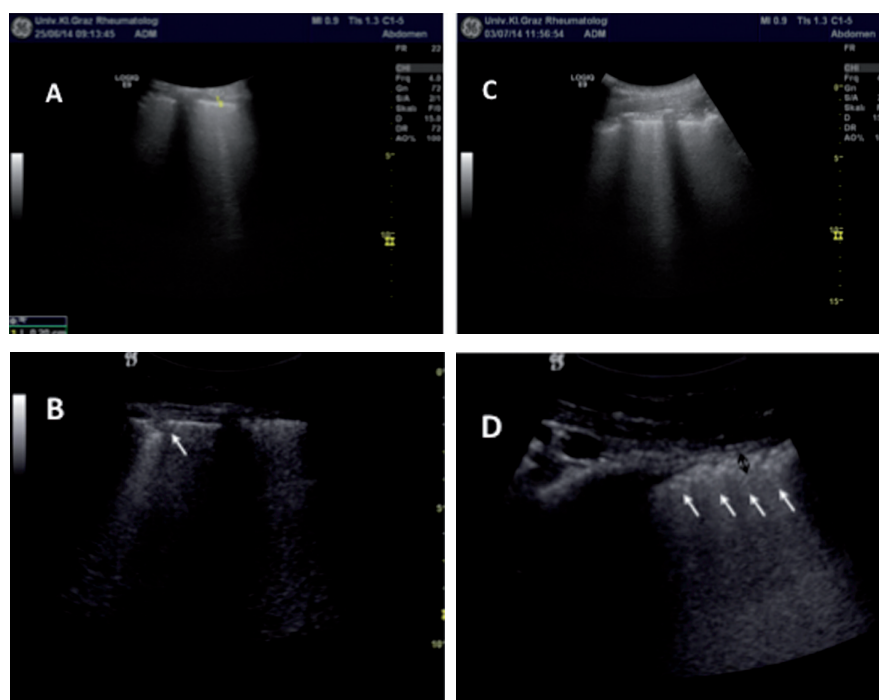
**Reverberation artifacts:** repetitive horizontal artifacts that arise from the pleural line and are generated by subpleural air. This ultrasound pattern is seen in healthy subjects (13, 14).

**B-lines/B-pattern (Fig. 3):** vertical artifacts arising from the pleural line; they reflect the coexistence of elements with a major acoustic impedance gradient. In previous studies, multiple B-lines or comet tail artefacts were reported to be present in lung diseases like pulmonary oedema, pulmonary fibrosis, pneumonia or acute respiratory distress syndrome (7, 9, 12, 17-19). If more than two B-lines were visible for both investigators in any scanned area, this area was regarded as abnormal. Depending on the number of these areas, patients were divided in three groups using a comet-score system. A comet-score of 0 was assigned to patients without positive areas, patients with 1-5 positive areas received a comet-score of 1 and patients with more than 5 abnormal areas got a comet-score of 2. The scoring system used for all ultrasound findings is described in Table II.

**Pleural line (Fig. 3):** the pleural line is a hyperechoic structure created by the parietal and visceral pleura, which indicates the lung surface. The normal pleural line appears regular without any thickenings. "Thickening" due to the irregularities of the pleural line more



**Fig. 3a.** Pleural irregularity in a healthy control (A), a RA patient (B) and a SLE (C) patient. Showing a small pleural "line" in A; in B, C pleural irregularities are present.



**Fig. 3b.** Appearance of B lines and a nodule in RA patients (A, B) and multiple B lines in scleroderma patients (C, D).

than 3 mm observed in any scanned area was defined to be pathologic (11, 14, 15). The same scoring system as described for B-lines was used to quantify pleural irregularities.

**Subpleural alterations:** the normal pleural surface appears thin and regular. Pleural nodes of several millimeters in size have previously been described to be present in miliary tuberculosis, sarcoidosis and rheumatoid arthritis (7,

11, 14). To semiquantitatively assess these pleural nodes we used an analogous scoring system as described for B lines/B-pattern and pleural thickenings. Each scanned area was defined to be positive, if one or more pleural nodes were visible on transthoracic ultrasound.

### Results

Twenty-eight percent (n=7) of the RA

**Table II.** Scoring system used to quantify findings in transthoracic ultrasound.

Score	0	1	2
Comet-tail artifacts / B-pattern	no area with predominant comet-tail artifacts	predominant comet-tail artifacts in 1-5 areas	>5 areas with predominant comet-tail artifacts
Pleural nodes	no area with one or more pleural nodes	one or more pleural nodes present in 1-5 scanned areas	>5 areas with one or more pleural nodes
Pleural thickenings >3 mm	no area with a thickened pleural line	pleural thickenings present in 1-5 areas	>5 areas with a thickened pleural line

**Table III.** Findings in transthoracic ultrasound in RA, SSC and SLE Patients with and without ILD.

	B lines/B-pattern	Pleural nodes	Thickened pleura >3 mm
RA + ILD (n=7)	100% (86% comet-score of 2; 14% comet-score of 1)	100% (71% node-score of 2, 29% node-score of 1)	86% (43% pleura-score of 2; 43% pleura-score of 1)
RA - ILD (n=18)	6% (6% comet-score of 1)	22% (22% node-score of 1)	11% (11% pleura-score of 1)
SSC + ILD (n=9)	100% (55% comet-score of 2, 45% comet-score of 1)	22% (22% node-score of 1)	100% (23% pleura-score of 2; 77% pleura-score of 1)
SSC - ILD (n=5)	40% (40% comet-score of 1)	0%	0%
SLE + ILD (n=4)	100% (75% comet-score of 2, 25% comet-score of 1)	50% (50% node-score of 1)	100% (100% pleura-score of 1)
SLE - ILD (n=2)	0%	0%	50% (50% pleura-score of 1)

cohort, 64% (n=9) of the SSC patients and four out of six SLE patients showed signs of pulmonary fibrosis on HRCT. Based on the scoring system described above ultrasound findings were assessed semiquantitatively (Table III) and compared to HRCT.

Comet-tail artifacts/B-patterns were present in all patients (100%) of the ILD group (n=20) but only in 12% of the patients with normal CT-scans (n=25) ( $p<0.001$ ). Subpleural nodes were observed in 55% (n=11) of the ILD patients compared to 17% (n=4) of the patients without radiological signs of ILD ( $p=0.006$ ). Ninety-five percent of the ILD (n=19) patients *versus* 12, 5% (n=3) of the non-ILD group showed pleural irregularities >3 mm on thoracic ultrasound ( $p<0.001$ ). In healthy volunteer B lines were observed in 3 patients (7%) and pleural noduli in one (2%) patient.

All RA patients (n=7) with ILD showed pleural nodes on thoracic ultrasound, whereas these findings were observed in only 22% (n=2) of the SSC patients ( $p=0.003$ ) and 50% (n=2) of the SLE patients ( $p=0.049$ ). An irregular pleural line >3 mm was documented in 100% of SSC (n=9) and SLE patients (n=4) with ILD, but only in 86% (n=6) of ILD patients suffering from RA ( $p=ns$ ).

**Discussion**

For a long time ultrasonography has been regarded as inapplicable for the assessment of lung diseases, because the ultrasonic waves are erased by the air-containing lung surface, which leads to reverberation artifacts. However, in the past few decades a growing number of studies were conducted to assess the diagnostic value of sonography in lung diseases. Nowadays lung sonography is a commonly accepted tool in the diagnosis of solid lesions of the pleura and the lung (pneumonia, pulmonary embolism, neoplasms) and interstitial lung diseases such as pulmonary oedema and acute respiratory distress syndrome as well. We choose the study design of 18 locations since we are experienced in that setting (15) and Guitierrez *et al.* published that in fibrotic disease fewer locations would be needed for evaluation (20).

In previous studies B lines were found to be present in diseases associated with thickened pleural interlobular septa. In our study all patients with ILD showed multiple B lines (B-pattern) on ultrasonography, corresponding well to the findings of a study by Reissig and Kroegel, in which 98% of patients with diffuse parenchyma lung disease (DPLD) had multiple B lines per scan (7). Of course B patterns are

very unspecific for pulmonary fibrosis and occur in many different diseases such as pulmonary oedema, pneumonia and acute lung injury. Even in older healthy subjects B lines could be observed in up to 25% (13). In accordance to these findings, 12% of our study patients without ILD on HRCT revealed a comet score of 1. Since we have used lung ultrasonography in various clinical scenarios, we made the observation, that the sonographic aspect of B lines generated by pulmonary fibrosis is different to those due to pulmonary oedema. Normally “B lines” due to pulmonary fibrosis do not fulfil the sonographic criteria defined by Lichtenstein of so called B-Lines, which are highly suspicious for pulmonary oedema if predominant at the anterior and lateral chest wall. Volpicelli *et al.* actually described the B-Lines in fibrosis better to be described as “B pattern” (14). This also seems to be more appropriate in scleroderma. However, further prospective studies are needed to clarify this question.

In our study 95% of the ILD patients showed a thickened pleural line on thoracic ultrasound, which confirms previous findings (7). Interestingly 12% of the patients without ILD had a pleura-score of 1, whereas in prior studies none of the control patients showed this

ultrasound finding (7, 10). Due to ethical reasons we have not performed CT scans in healthy individuals. In autoimmune patients, sonographic changes in latero-basal areas of the lung parenchyma and simultaneously at the pleura occur even if computed tomography is normal.

Subpleural nodes could be detected in 50% of all ILD patients, which is in agreement with another study, which reported a frequency of 38% in patients with DPLD (7). Interestingly subpleural nodes were significantly more frequent in RA patients compared to those suffering from SLE and SSC, maybe indicating rheumatic nodes. On the other hand a thickened pleural line occurred more frequent in the case of SSC and SLE. However, due to the relatively small number of subjects this difference was not statistically significant. Our data matches the different findings described in the literature concerning lung fibrosis as a general result of different parenchymatous diseases, and allude to the possibility of detecting peripheral tissue changes other than end-stage fibrosis in rheumatic diseases. Moreover, these results are well in accordance with reports from series of patients with histologically proven interstitial lung disease and systemic autoimmune diseases (10).

The major limitation of our observational study is the small number of subjects investigated. To evaluate the place of transthoracic ultrasound as a diagnostic screening tool for early stage ILD in patients with rheumatic diseases, higher numbers of patients have to be enrolled in a prospective setting.

## Conclusion

The observations of our study confirm the results of previous studies and lead to the assumption, that transthoracic ultrasound of the lung might be a sensitive and non-invasive tool to observe interstitial lung disease in patients with rheumatic diseases.

## Acknowledgements

We thank Peter Zechner, who contributed to the development of our case report file.

## References

- CRYSTAL RG, BITTERMAN PB, MOSSMAN B *et al.*: Future research directions in idiopathic pulmonary fibrosis: summary of a National Heart, Lung, and Blood Institute working group. *Am J Respir Crit Care Med* 2002; 166: 236-46.
- OSTOJIC P, DAMJANOV N: Improvement of lung function in patients with systemic sclerosis after 6 months cyclophosphamide pulse therapy. *Clin Rheumatol* 2006; 25: 819-21.
- MARADIT-KREMERS H, NICOLA PJ, CROWSON CS, BALLMAN KV, GABRIEL SE: Cardiovascular death in rheumatoid arthritis: a population-based study. *Arthritis Rheum* 2005; 52: 722-32.
- BERNATSKY S, BOIVIN JF, JOSEPH L *et al.*: Mortality in systemic lupus erythematosus. *Arthritis Rheum* 2006; 54: 2550-7.
- SCREATON NJ, HIORNS MP, LEE KS *et al.*: Serial high resolution CT in non-specific interstitial pneumonia: prognostic value of the initial pattern. *Clin Radiol* 2005; 60: 96-104.
- DIOT E, BOISSINOT E, ASQUIER E *et al.*: Relationship between abnormalities on high-resolution CT and pulmonary function in systemic sclerosis. *Chest* 1998; 114: 1623-9.
- REISSIG A, GORG C, MATHIS G: Transthoracic sonography in the diagnosis of pulmonary diseases: a systematic approach. *Ultraschall Med* 2009; 30: 438, 54; quiz 455-6.
- WOHLGENANT S, GEHMACHER O, GEHMACHER U, KOPF A, MATHIS G: Sonographic findings in interstitial lung diseases. *Ultraschall Med* 2001; 22: 27-31.
- LICHTENSTEIN DA, MEZIERE GA: Relevance of lung ultrasound in the diagnosis of acute respiratory failure: the BLUE protocol. *Chest* 2008; 134: 117-25.
- SPERANDEO M, VARRIALE A, SPERANDEO G *et al.*: Transthoracic ultrasound in the evaluation of pulmonary fibrosis: our experience. *Ultrasound Med Biol* 2009; 35: 723-9.
- MOAZEDI-FUERST FC, KIELHAUSER SM, SCHEIDL S *et al.*: Ultrasound screening for interstitial lung disease in rheumatoid arthritis. *Clin Exp Rheumatol* 2014; 32: 199-203.
- PINAL FERNANDEZ I, PALLISA NUNEZ E, SELVA-O'CALLAGHAN A, CASTELLA-FIERRO E, MARTINEZ-GOMEZ X, VILARDELL-TARRES M: Correlation of ultrasound B-lines with high-resolution computed tomography in antisynthetase syndrome. *Clin Exp Rheumatol* 2014; 32: 404-7.
- VOLPICELLI G, CARAMELLO V, CARDINALE L, MUSSA A, BAR F, FRASCISCO MF: Detection of sonographic B-lines in patients with normal lung or radiographic alveolar consolidation. *Med Sci Monit* 2008; 14: CR122-8.
- VOLPICELLI G, ELBARBARY M, BLAIVAS M *et al.*: International evidence-based recommendations for point-of-care lung ultrasound. *Intensive Care Med* 2012; 38: 577-91.
- MOAZEDI-FUERST FC, ZECHNER PM, TRIPOLT NJ *et al.*: Pulmonary echography in systemic sclerosis. *Clin Rheumatol* 2012; 31: 1621-5.
- REMY-JARDIN M, REMY J, CORTET B, MAURI F, DELCAMBRE B: Lung changes in rheumatoid arthritis: CT findings. *Radiology* 1994; 193: 375-82.
- LICHTENSTEIN D, MEZIERE G: A lung ultrasound sign allowing bedside distinction between pulmonary edema and COPD: the comet-tail artifact. *Intensive Care Med* 1998; 24: 1331-4.
- DOVERI M, FRASSI F, CONSENSI A *et al.*: Ultrasound lung comets: new echographic sign of lung interstitial fibrosis in systemic sclerosis. *Reumatismo* 2008; 60: 180-4.
- GARGANI L, DOVERI M, D'ERRICO L *et al.*: Ultrasound lung comets in systemic sclerosis: a chest sonography hallmark of pulmonary interstitial fibrosis. *Rheumatology (Oxford)* 2009; 48: 1382-7.
- GUTIERREZ M, SALAFFI F, CAROTTI M *et al.*: Utility of a simplified ultrasound assessment to assess interstitial pulmonary fibrosis in connective tissue disorders--preliminary results. *Arthritis Res Ther* 2011; 13: R134.