

## SHORT REPORT

# Overall mortality in combined pulmonary fibrosis and emphysema related to systemic sclerosis

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**ABSTRACT**

**Objectives** This multicentre study aimed to investigate the overall mortality of combined pulmonary fibrosis and emphysema (CPFE) in systemic sclerosis (SSc) and to compare CPFE-SSc characteristics with those of other SSc subtypes (with interstitial lung disease—ILD, emphysema or neither).

**Methods** Chest CTs, anamnestic data, immunological profile and pulmonary function tests of patients with SSc were retrospectively collected. Each chest CT underwent a semiquantitative assessment blindly performed by three radiologists. Patients were clustered in four groups: SSc-CPFE, SSc-ILD, SSc-emphysema and other-SSc (without ILD nor emphysema). The overall mortality of these groups was calculated by Kaplan-Meier method and compared with the stratified log-rank test; Kruskal-Wallis test, t-Student test and  $\chi^2$  test assessed the differences between groups.  $P < 0.05$  was considered statistically significant.

**Results** We enrolled 470 patients (1959 patient-year); 15.5% (73/470) died during the follow-up. Compared with the SSc-ILD and other-SSc, in SSc-CPFE there was a higher prevalence of males, lower anticentromere antibodies prevalence and a more reduced pulmonary function ( $p < 0.05$ ). The Kaplan-Meier survival analysis demonstrates a significantly worse survival in patients with SSc-CPFE (HR vs SSc-ILD, vs SSc-emphysema and vs other-SSc, respectively 1.6 (CI 0.5 to 5.2), 1.6 (CI 0.7 to 3.8) and 2.8 (CI 1.2 to 6.6)).

**Conclusions** CPFE increases the mortality risk in SSc along with a highly impaired lung function. These findings strengthen the importance to take into account emphysema in patients with SSc with ILD.

**INTRODUCTION**

As interstitial lung disease (ILD) increases the mortality in systemic sclerosis (SSc),<sup>1</sup> many studies are focusing on predictive factors of

**Key messages****What is already known about this subject?**

► Combined pulmonary fibrosis and emphysema (CPFE) was observed in short-survival IPF patients and in SSc subjects with a relevant decrease in FVC and a DLco.

**What does this study add?**

► This is the first study describing a more reduced survival in SSc-CPFE compared with other SSc subgroups.

**How might this impact on clinical practice?**

► CPFE is a radiological pattern that should always be considered in SSc chest CT assessment  
► CPFE detection can be useful in order to select patients with a more severe SSc.

survival. Pulmonary function tests (forced vital capacity—FVC and diffusion lung capacity of CO—DLco) and semiquantitative assessment of ILD extension detectable in chest CT (sQCT), are the most important.<sup>2</sup> In particular, FVC and DLco are quite diffused and they play a pivotal role in the diagnostic and therapeutic decision making process.

Combined pulmonary fibrosis and emphysema (CPFE) is a lung affection characterised by the presence of ILD and emphysema. CPFE was observed in short-survival IPF patients, even non-smokers.<sup>3</sup> Other following studies supported the hypothesis that emphysema is an independent mortality risk factor in ILD.<sup>4</sup>

Cottin *et al.* reported 34 cases of CPFE in connective tissue disease for the first time.<sup>5</sup> In the next years, some authors presented cases

**Table 1** Patients characteristics

|  | Total               | Other-SSc           | SSc-emphysema       | SSc-ILD             | SSc-CPFE            | P value   |
|--|---------------------|---------------------|---------------------|---------------------|---------------------|---|
| n (%)                                  | 470 (100)           | 202 (43)            | 29 (6)              | 196 (42)            | 43 (9)              | –   |
| Age, mean (year) (95% CI)              | 59.2 (57.2 to 60.5) | 59.3 (57.3 to 61.3) | 59.8 (54.8 to 64.9) | 59.4 (57.4 to 61.3) | 57.7 (53.3 to 62.1) | nss   |
| Sex (M:F)                              | 90:380              | 30:172              | 8:21                | 36:160              | 16:27               | (CPFE vs SSc-ILD)**<br>(CPFE vs Other-SSc)***   |
| Disease duration, mean (year) (95% CI) | 8.2 (7.4 to 8.9)    | 7.8 (6.6 to 9.0)    | 8.4 (5.3 to 11.5)   | 8.4 (7.4 to 9.5)    | 8.6 (6.1 to 11)     | nss   |
| Smoke habit† (none:former:current)     | 351:57:52           | 165:17:19           | 17:5:6              | 146:28:18           | 25:7:9              | (CPFE vs Other-SSc)**<br>(SSc-Emphysema vs Other-SSc)*  |
| ACA prevalence (n)                     | 160                 | 107                 | 21                  | 27                  | 5                   | (CPFE vs SSc-Other)§<br>(CPFE vs SSc-Emphysema)§<br>(SSc-ILD vs SSc-Emphysema)§<br>(SSc-Other vs SSc-Emphysema)*<br>(Other-SSc vs SSc-ILD)§ |
| anti Scl70 prevalence (n)              | 154                 | 23                  | 0                   | 113                 | 18                  | (CPFE vs SSc-Emphysema)***<br>(CPFE vs Other-SSc)§<br>(SSc-ILD vs SSc-Emphysema)§<br>(SSc-ILD vs Other-SSc)§                                |
| FVC-predicted, mean (95% CI)           | 99% (97 to 102)     | 109% (105 to 113)   | 103% (92 to 114)    | 91% (88 to 95)      | 88% (80 to 95)      | (CPFE vs Other-SSc)†<br>(CPFE vs SSc-Emphysema)**<br>(Other-SSc vs SSc-ILD)†<br>(SSc-ILD vs SSc-Emphysema)*                                 |
| TLC-predicted, mean (95% CI)           | 93% (90 to 95)      | 99% (96 to 103)     | 104% (93 to 116)    | 85% (81 to 89)      | 82% (76 to 88)      | (CPFE vs Other-SSc)†<br>(CPFE vs SSc-Emphysema)†<br>(SSc-ILD vs SSc-Emphysema)†<br>(Other-SSc vs SSc-ILD)†                                  |
| DLco-predicted, mean (95% CI)          | 65% (63 to 67)      | 73% (70 to 75)      | 63% (55 to 65)      | 61% (58 to 64)      | 48% (42 to 55)      | (CPFE vs Other-SSc)†<br>(CPFE vs SSc-ILD)†<br>(CPFE vs SSc-Emphysema)**<br>(SSc-Other vs SSc-Emphysema)*<br>(Other-SSc vs SSc-ILD)***       |
| DLco/VA-predicted, mean (95% CI)       | 82% (80 to 85)      | 85% (81 to 88)      | 83% (75 to 91)      | 85% (81 to 89)      | 59% (52 to 67)      | (CPFE vs SSc-ILD)†<br>(CPFE vs Other-SSc)†<br>(CPFE vs SSc-Emphysema)†  |
| ILD extent >20%, n (%)                 | 95 (20)             | 0 (0)               | 0 (0)               | 74 (38)             | 21 (49)             | (CPFE vs Other-SSc)§<br>(CPFE vs SSc-Emphysema)§<br>(SSc-ILD vs SSc-Emphysema)§<br>(Other-SSc vs SSc-ILD)§                                  |
| sQCT of ILD, median (95% CI)           | 1% (0 to 3)         | 0                   | 0                   | 15% (13 to 17)      | 20% (18 to 26)      | (CPFE vs Other-SSc)†<br>(CPFE vs SSc-ILD)**<br>(CPFE vs SSc-Emphysema)†<br>(SSc-ILD vs SSc-Emphysema)†<br>(Other-SSc vs SSc-ILD)***         |
| sQCT of emphysema, median (95% CI)     | 0                   | 0                   | 4% (2 to 10)        | 0                   | 4% (2 to 7)         | (CPFE vs SSc-ILD)†<br>(CPFE vs Other-SSc)†<br>(SSc-Emphysema vs SSc-ILD)†<br>(SSc-Emphysema vs Other-SSc)†                                  |

A graphical presentation of key findings is in the online supplementary file 1.

\* $<0.05$ ; \*\* $<0.01$ ; \*\*\* $<0.001$ .

† $<0.005$ .

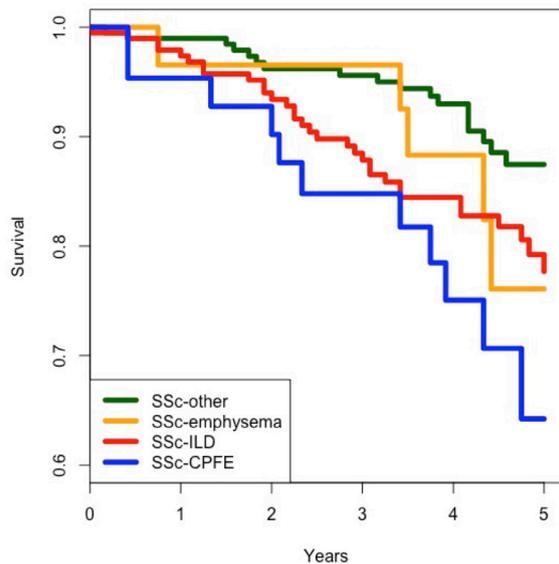
‡Ten patients had an unknown smoke habit.

§ $<0.0001$ .

ACA, anticentromere antibodies; CPFE, combined pulmonary fibrosis and emphysema; DLco, diffusion lung capacity of CO; FVC, forced vital capacity; ILD, interstitial lung disease; IPF, Idiopathic pulmonary fibrosis; SSc, systemic sclerosis; TLC, Total lung capacity; VA, alveolar volume.

of SSc-ILD affected by severe emphysema.<sup>6</sup> Recently, Antoniou *et al* described the characteristics of a cohort of SSc-CPFE.<sup>7</sup> These patients had almost normal FVC and a DLco considerably decreased. These findings arise a discussion on the possible bias that FVC assessment and

lack of pulmonary hypertension measurement could generate in this subgroup of SSc-ILD but were inconclusive about CPFE role in SSc.<sup>8</sup> Especially, it remains not clear if CPFE is associated with a decreased survival in SSc.



**Figure 1** Survival in SSc-CPFE, SSc-ILD, SSc-emphysema and other-SSc. CPFE, combined pulmonary fibrosis and emphysema; ILD, interstitial lung disease; SSc, systemic sclerosis.

The main aim of this study was to investigate the overall mortality of CPFE in patients with SSc. The secondary objective was to compare SSc-CPFE characteristics versus those of patients with SSc affected by ILD (SSc-ILD), emphysema (SSc-emphysema) or neither of them (other-SSc).

## METHODS

This study was conducted according to the Declaration of Helsinki. The Institutional Review Boards approved the study protocol; all patients provided informed consent.

### Patients

Four-hundred and seventy (470) consecutive patients fulfilling the ACR/EULAR classification criteria<sup>9</sup> for SSc were enrolled. Exclusion criteria were age <18 years and follow-up data available. The survival time was considered the time interval between the CT date and the death or the last clinic visit.

### Pulmonary function tests

FVC and DLco performed within 6 months from CT were recorded. All centres performed PFTs according to the ATS/ERS standards.

### sQCT assessments

Three thoracic radiologists scored the CT images as previously proposed.<sup>7</sup> On the basis of the sQCT, four subgroups were identified: (1) SSc-other (neither ILD nor emphysema); (2) SSc-emphysema (exclusive presence of

emphysema); (3) SSc-ILD (exclusive presence of ILD); (4) CPFE (presence of ILD and emphysema).

### Statistical analysis

Statistical analysis was performed using R (<http://www.r-project.org>, V.3.3.3). Kaplan-Meier survival analysis and log-rank test verified the difference between the four subgroups. The HR with 95% CI was calculated according to Klein & Moeschberger method.  $P < 0.05$  was considered statistically significant.

More information are in the online supplementary file 1.

## RESULTS

This study included 1959 patient-year with a median follow-up of 4.2 (CI 3.9 to 4.3) years; 15% of patients (72/470) died. Patients' characteristics are listed in table 1.

CPFE prevalence was 18% in patients with ILD and 7% in never smokers. Patients with CPFE had the highest male prevalence and the lowest DLco ( $p < 0.05$ ). CPFE and SSc-ILD had a similar autoimmune profile, which was different from patients with SSc-emphysema and other SSc ( $p < 0.0005$ ). In CPFE, there was a more relevant lung impairment (fibrosis extent and pulmonary function decrease) than in the other three subgroups ( $p < 0.01$ ). In SSc-emphysema, we observed the highest anticentromere antibodies prevalence ( $p < 0.05$ ) and a DLco decrease (similar to SSc-ILD, lower than in other-SSc and higher than in SSc-CPFE and SSc-ILD). The extent of emphysema was similar in the SSc-CPFE and SSc-emphysema subgroups.

The Kaplan-Meier survival analysis demonstrated a worse survival in SSc-CPFE compared with other-SSc ( $p < 0.01$ ) and SSc-ILD or SSc-emphysema ( $p = 0.1$ ) (figure 1). The HR was, respectively, 2.8 (CI 1.2 to 6.6), 1.6 (CI 0.7 to 3.8) and 1.6 (IC 0.5–5.2).

## DISCUSSION

This is the largest population of CPFE related to SSc ever described. Our observations about pulmonary function impairment, disease duration and smoke habit are similar to those of previous studies.<sup>5–7</sup> We confirm that CPFE decreases gas exchange more than ILD or emphysema alone; on the other hand, pulmonary static volumes are little or not affected.

Lung impairment (ILD, emphysema or both of them) appears to be related to a higher risk of death and a decrease of pulmonary function. ILD is a predictor of mortality,<sup>1</sup> while emphysema presence was never taken into account. The detection of emphysema in never smokers was so far neglected, yet we showed that it deserves clinical attention.

Our findings confirm previous hypothesis about the role of emphysema in patients with SSc with pulmonary fibrosis that namely it is a synergistic risk factor.<sup>5</sup> So, emphysema combined with pulmonary fibrosis is a

radiological pattern that should be considered in chest CT assessment. CPFE detection can be useful in order to select patients with an increased risk of mortality related to more severe SSs.

This study has the limitations of a retrospective design. In particular, there was not a control group of IPF-CPFE subjects, only two antibody patterns were recorded as far as the smoke habit duration (that is likely to have been a risk factor for emphysema onset). Moreover, the definition of CPFE is not clear. In the first studies, CPFE diagnosis was based on imaging features.<sup>5</sup> We classified CPFE if sQCT of ILD and emphysema was  $\geq 1\%$ , as Antoniou *et al* proposed.<sup>7</sup> However, this approach does not take into account the emphysema type, distribution and proximity to fibrotic lesions. Walsh *et al*<sup>10</sup> showed that traction bronchiectasis are strongly associated with mortality in ILD related to connective tissue disease. So it is impossible to exclude that emphysema-like lesions near to fibrosis are an expression of ILD severity.

In conclusion, CPFE increases the risk of mortality and it should always be sought in order to better outline the prognosis in patients with SSs.

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