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OESOPHAGEAL DILATATION ON CHEST HIGH-RESOLUTION COMPUTED TOMOGRAPHY IN SYSTEMIC SCLEROSIS

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Abstract

Aim: The present study was conducted to determine the relationship between oesophageal diameter and disease findings in patients with systemic sclerosis.

Material and Methods: The study included 86 patients. A retrospective evaluation was performed on the demographic data, biochemical and serological tests, and chest high-resolution computed tomography (HRCT) images of the patients. The presence of dilatation was defined as a measurement of over 10 mm in width. The oesophageal area was calculated at the level of the widest measurement. The relationship between oesophageal dilatation and digital ulcer (DU), pulmonary involvement, and pulmonary hypertension was evaluated.

Results: The number of patients with supra-aortic and infra-aortic esophageal lateral, anteroposterior, and widest esophageal dilatation measurements above 10 mm was 49 (56.9%). The largest oesophageal area was found to be 173.6±90.7 mm^2. The prevalence of DUs did not differ significantly between the groups with and without oesophageal dilatation. Pulmonary hypertension was detected in 22 (44.9%) patients with oesophageal dilatation and was found to be significantly higher in those without oesophageal dilatation (p=0.04). The extent of pulmonary involvement was significantly higher in the group with oesophageal dilatation (p=0.003).

Conclusion: The oesophageal diameter has been demonstrated to be associated with pulmonary involvement. HRCT offers a valuable opportunity to assess the oesophagus. Further research is required to ascertain whether oesophageal diameter can be utilised in HRCT evaluations as a means of patient monitoring.

Keywords: Computed tomography, oesophageal dilatation, systemic sclerosis, pulmonary involvement

INTRODUCTION

Systemic sclerosis (SSc) is a rare connective tissue disease characterised by diffuse fibrosis of the skin and organs. The gastrointestinal system is affected in over 90% of patients. It shows a heterogeneous involvement and may occur at any stage of the disease course (1). The underlying pathophysiology of gastrointestinal system involvement, especially in the oesophagus, remains to be fully elucidated. The prevailing hypothesis suggests that neural dysfunction, muscle atrophy, vascular problems, and fibrosis are the primary factors contributing to the pathology of the disease (2-4). The findings from autopsy studies indicate that smooth muscle atrophy is a

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predominant feature in oesophageal lesions, particularly within the circular layer. These findings suggest that this phenomenon is not associated with ischaemic and inflammatory conditions. The targeted destruction of smooth muscle cells by autoimmunity, in conjunction with neuromuscular structures like muscarinic receptor swhich play a pivotal role in smooth muscle stimulation and autonomic dysfunction, has been identified as a causative factor for smooth muscle atrophy. The loss of Interstitial Cells of Cajal (ICC) has also been identified. ICC provides smooth muscle pacemaker activity and is part of the sensory units of vagal afferents. The involvement of the vagus nerve, a component of the autonomous nervous system that plays a crucial regulatory role in oesophageal motility and sphincter function, has been identified as a contributing factor to SSc oesophageal involvement (5,6).

SSc-related pulmonary involvement, characterized by pulmonary arterial hypertension and interstitial lung disease (ILD) is the most significant predictor of mortality. The prevalence of SSc-related pulmonary involvement is higher in the diffuse cutaneous form, with a 10-year mortality rate that exceeds 40%. Consequently, it is recommended that patients diagnosed with SSc be screened for ILD by high-resolution computed tomography (HRCT) (7,8). The presence of digital ulceration and pulmonary hypertension is recognised as a risk factor for the development and progression of ILD (9). An increase in oesophageal diameter is considered a risk factor for ILD progression and is associated with an increased risk of death. Increased oesophageal diameter has been demonstrated to result in impaired motility and microaspiration of gastric contents. The role of microaspiration in the initiation and progression of ILD has been a subject of research (7,10).

The oesophagus in SSc is dilated and exhibits a loss of function, contrary to the usual narrowing of the structure. HRCT, utilised for the assessment of ILD, frequently reveals dilated oesophagus, in SSc patients; however, this finding is often overshadowed by the evaluation of lung parenchyma. The present study was conducted with the objective of determining the relationship between oesophageal diameter and disease findings in patients with SSc.

MATERIAL AND METHODS

Study Population

The present cross-sectional, retrospective study comprised 86 patients aged 18 years and over who were followed up in the rheumatology clinic between 2019 and 2024 and had been diagnosed with SSc according to the 2013 American College of Rheumatology/European League Against Rheumatism Classification Criteria for SSc (11). All patients for whom laboratory and HRCT data were available were included in the study. Patients under 18 years of age and those with inaccessible or missing data were excluded from the study. The demographic data, biochemical and serological tests, echocardiography, pulmonary function tests, and HRCT images of the patients were evaluated retrospectively. The clinical information, including the number of hand and foot digital ulcers (DUs), was obtained by analysing the patient files. Patients were categorised as limited cutaneous or diffuse cutaneous according to the LeRoy classification system (12) after physical examination by an experienced rheumatologist.

The clinical definition of DUs is as follows: areas of the fingers with a visually noticeable depth and loss of continuity of epithelial cover. The severity of DU was determined by the number of new DUs reported by the physician during the clinical examination. The severity of DU was categorised as follows: 0-5 DUs were defined as mild, 6-10 DUs as moderate, and >10 DUs as severe (13,14).

The anti-nuclear antibody (ANA) test was conducted using the indirect immunofluorescence (IIF) method, with HEp-2 (HEp-2000) cells serving as the substrate. The screening dilution was set at 1/160. Values below 1/160 titre were evaluated as negative, 1/160-1/320 titre 1+, 1/320-1/640 titre 2+, 1/640-1/1280 titre 3+, and >1/1280 titre 4+.

Transthoracic echocardiography was conducted within the echocardiography laboratory of the department of Cardiology, utilising a high-resolution Philips IE 33 imaging system (Andover, Massachusetts, USA) with transducers arranged at varying frequencies (2.5-3.5 MHz). Tricuspid regurgitation velocity >2.8 m/s and pulmonary artery pressures (PAPs) ≥35 mmHg, as determined by transthoracic echocardiography, were identified as indicators of pulmonary hypertension. Right heart catheterisation (RHC) was then performed in these patients in accordance with a standard protocol. During RHC, mPAP and pulmonary capillary wedge pressure were measured by placing the catheter. Pulmonary hypertension was diagnosed when the mean arterial pulmonary pressure was >20 mmHg on RHC at rest (15).

The evaluation of lung involvement was conducted through the use of HRCT, pulmonary function tests, and diffusing capacity of the lungs for carbon monoxide (DLCO). Determination of lung involvement was conducted exclusively through HRCT by a radiologist with expertise in this domain. A pathological diagnosis (lung biopsy) was not undertaken. The classification of the subject is as follows: NSIP, UIP, or possible UIP, according to the image type on HRCT. Patients were selected for medical

treatment in accordance with the treatment algorithm using HRCT, as outlined in the Expert consensus on the management of SSc-associated ILD. Patients with greater than 20% lung parenchymal involvement, along with forced vital capacity (FVC) and/or DLCO levels below the lower limit of normal, and moderate to severe symptoms, were initiated on medical treatment. While the patients included in the study received medical treatment for ILD, determining whether there was lung involvement, the type of involvement was determined by HRCT findings. Patients who did not fulfil the treatment criteria were not considered to have lung involvement (8).

Ethics committee approval for this retrospective study was obtained from the Süleyman Demirel University Faculty of Medicine Ethics Committee (approval number: 2024/83/25, dated: 05.11.2024).

Esophageal Measurements on High-Resolution CT

HRCT scans were obtained in the supine position during full inspiration using a SOMATOM Definition AS (Siemens Medical Systems, Iselin, NJ). HRCT was performed from the lung apices to the lung bases. In the axial sections of HRCT, the oesophagus was divided into two regions: supra-aortic and infra-aortic, according to their position relative to the upper border of the aortic arch. The presence of dilatation was defined as a measurement of over 10 mm in width. Supra-aortic and infra-aortic, lateral, antero-posterior, and widest measurements were taken. The oesophageal area was calculated at the level of the widest measurement (Figure 1) (16).

Supra-aortic and infra-aortic measurements, as well as oesophageal area calculations, were performed separately by both authors. The results demonstrated substantial agreement (Fleiss's Kappa 0.68) among the supra-aortic and infra-aortic measurements, and the oesophageal area.

Statistical Analysis

The data obtained from the study were analysed using the IBM SPSS 29.0 software package (Statistical Package for the Social Sciences, IBM, USA). Descriptive statistics were employed to present categorical data as frequencies and percentages and proportional scale data as mean ± standard deviation. The Kolmogorov-Smirnov method, the Student's t-test, and chi-square analysis were utilized in the analysis. The Kolmogorov-Smirnov method was employed to test the normal distribution of continuous numerical data, with parametric methods subsequently used to conduct comparisons between groups and repeated measurements. The Student's t-test was employed to compare two independent groups, and the paired t-test was used to compare two repeated measures. Chi-square analysis was used to determine the relationships between categorical data. The study found that the p-value was considered significant when it was less than 0.05, with a Type-I error rate of 5% throughout the study. The maximum accepted value of the type 2 error (beta) was 0.20.

RESULTS

The study included 86 patients. It appears that the number of patients with supra-aortic and infra-aortic oesophageal lateral, anteroposterior, and widest oesophageal dilatation measurements above 10 mm was 49 (56.9%). Patients were divided into two groups: one with oesophageal dilatation and one without. In patients with oesophageal dilatation, supraaortic oesophagus's widest lateral measurement was 13.4±5.8 mm and infraaortic oesophagus's widest lateral measurement was 14.6±6.7 mm. The supraaortic oesophagus anterior-posterior measured 9.2±4.9 mm, whereas the infraaortic oesophagus anterior-posterior measured 8.3±4.6 mm. The largest oesophageal area was found to be 173.6±90.7 mm2 (Table 1). The mean age of the group with oesophageal dilatation was

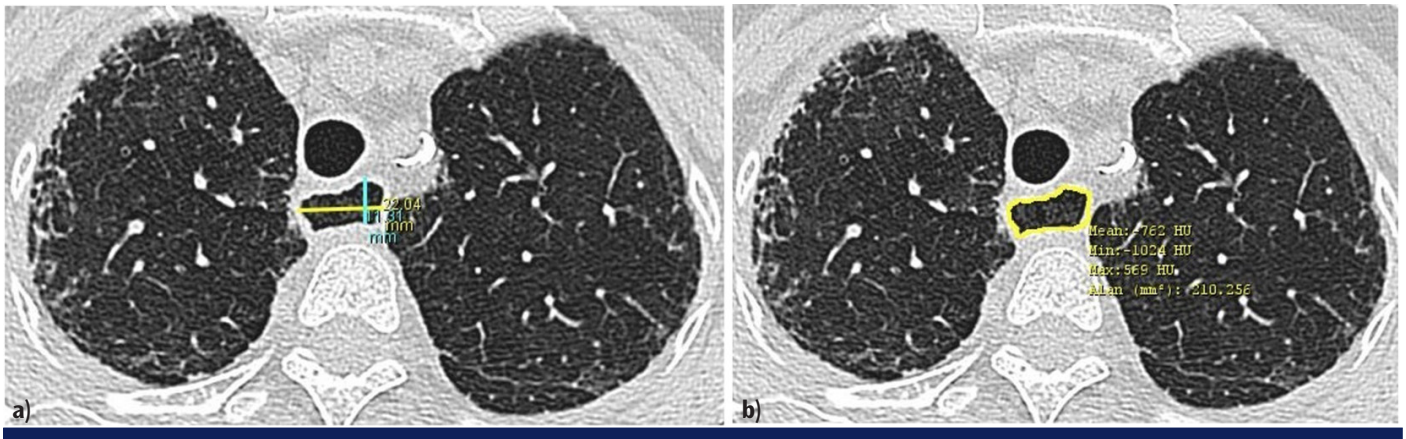

Figure 1. An example for measuring the largest oesophageal lateral and anteroposterior diameter (a) and maximal oesophageal area (b)

found to be significantly older than that of the group without oesophageal dilatation, with a statistically significant difference (p=0.04). Both groups were similar and had a preponderance of female patients and were similar. It appears that there is no significant difference between the two groups in terms of ANA titres and patterns. Anti-topoisomerase I (Anti Scl-70) and anti-centromere antibody positivity rates appeared to be similar. The rheumatoid factor positivity rate was 16 (32.7%) in the group with a dilated oesophagus and 5 (13.5%) in the group without a dilated oesophagus, indicating a statistically significant difference (Table 1).

An analysis of the clinical findings of patients with oesophageal dilatation revealed that the prevalence of DUs did not differ significantly between the study groups. When DUs were categorised, according to the scale employed, based on the number of lesions present, namely as Mild (1-5), Moderate (6-10), or Severe (>10), it was observed that the two groups exhibited comparable numbers and severity of DUs. Pulmonary hypertension was detected in 22 (44.9%) patients with oesophageal dilatation and was found to be statistically significantly higher in patients without oesophageal dilatation (p=0.04). When the number of patients with pulmonary involvement was analysed, the analysis showed that the degree of involvement was significantly higher in the group with oesophageal dilatation. The former group exhibited a prevalence of 32 (65%), while the latter group demonstrated a prevalence of 12 (32.4%) (p=0.003). Furthermore, the analysis of the specific types of pulmonary involvement revealed that NSIP was observed to be highly prevalent in both groups, being 93% in one group and 100% in the other, as illustrated in Table 2.

Binary logistic regression analysis revealed no statistically significant results concerning the factors influencing oesophageal

Table 1. Sociodemographic and laboratory data of the SSc patients

Variable	Oesophageal dilatation		p-value
	Yes (n=49)	No (n=37)	
Age, year	60.3±14.4	53.7±15.4	0.04*
Female, n	44 (89.8%)	35 (94.6%)	0.42
Age at diagnosis, year	51.4±15.6	46.9±14.7	0.08
Disease duration, months	110.6±75	82.7±63.5	0.07
ANA positive, n	48 (98%)	35 (94.6%)	0.40
ANA titer **<1/160 negative** **1/160-1/320 1+** **1/320-1/640 2+** **1/640-1/1280 3+** **>1/1280 4+**	 1 (2%) 5 (10.2%) 11 (22.4%) 19 (38.8%) 13 (26.5%)	 2 (5.4%) 3 (8.1%) 7 (18.9%) 17 (45.9%) 8 (21.6%)	0.88
ANA pattern **Speckled** **Homogenous** **Nucleolar** **Centromere** **Other**	 3 (6.1%) 15 (30.6%) 6 (12.2%) 21 (42.9%) 3 (6.1%)	 2 (5.4%) 11 (29.7%) 5 (13.5%) 16 (43.2%) 1 (2.7%)	0.96
SSc Subtypes **Diffuse cutaneous** **Limited cutaneous**	 26 (53.1%) 23 (46.9%)	 19 (51.4%) 18 (48.6%)	0.87
Anti-topoisomerase I (anti-Scl-70)	19 (38.8%)	10 (27%)	0.25
Anti-centromere	19 (38.8 %)	15 (40.5%)	0.86
RF positive, n	16 (32.7 %)	5 (13.5%)	**0.04***
Widest oesophageal diameter lateral, mm	14.61±6.79	-	
Widest oesophageal diameter, antero-posterior, mm	9.24±4.9	-	
Oesophageal area, mm²	173.6±90.7	-	

*: Significant at 0.05 level, calculated as mean ± standard deviation. NS: Not significant, SSc: Systemic sclerosis, ANA: Anti-nuclear antibody, RF: Rheumatoid factor

dilatation. However, when the factors affecting diffuse cutaneous SSc subtype were analysed, age and pulmonary involvement were found to be statistically significant [p-value 0.002 and <0.001, odds ratio: 0.934 (0.895-0.976), 31.003 (7.736-124.25), respectively] (Table 3).

DISCUSSION

In this study, we found that pulmonary hypertension and pulmonary involvement were more prevalent in SSc patients with oesophageal dilatation. Contrary to expectations, no correlation was found between dilatation and many other laboratory and clinical findings. As SSc is a fibroinflammatory disease, it is expected that laboratory data will not be normal in follow-up. However, a condition such as DUs, in which the role of vascular bed disorder and fibrosis in the pathophysiology is clear, would be expected to be associated with oesophageal dilatation. The relationship not being found in the study suggests that different factors are involved. The oesophagus is one of the organs frequently affected in SSc patients. In SSc patients presenting with GERD and dysmotility symptoms, a range of methods is employed to evaluate oesophageal involvement, including manometry, scintigraphy, and endoscopy. Consequently, a symptom-based screening procedure is performed in patients with gastrointestinal symptoms. However, all patients diagnosed with SSc are screened for lung involvement with HRCT because lung involvement is an important cause of mortality, and this screening also creates a good opportunity to evaluate the oesophagus even in asymptomatic patients. However, in clinical practice, the increase in oesophageal diameter is generally disregarded when evaluating the lung parenchyma, both at the time of initial diagnosis and during follow-up. However, since the early 2000s, it has been established that an increase in oesophageal diameter functions as a risk factor for ILD progression (9).

Table 2. Clinical findings of SSC patients according to Oesophageal dilatation

Variable	Oesophageal dilatation		p-value
	Yes (n=49)	No (n=37)	
Digital ulcer, n	30 (61.2 %)	16 (43.2%)	**0.09**
Number of digital ulcers **Mild (1-5)** **Moderate (6-10)** **Severe (>10)**	 22 (73.3 %) 6 (20 %) 2 (6.7 %)	 12 (75%) 3 (18.8%) 1 (6.2%)	0.99
Pulmonary hypertension, n	22 (44.9 %)	9 (24.3%)	**0.04***
Pulmonary involvement, n	32 (65 %)	12 (32.4%)	**0.003***
Pulmonary involvement type **NSIP** **UIP**	 30 (93.7 %) 2 (6.3 %)	 12 (100%) 0 (0%)	**0.01***

*: Significant at 0.05 level, calculated as mean ± standard deviation. NS: Not significant, NSIP: Non-specific interstitial pneumonia, UIP: Usual interstitial pneumonia

Table 3. Factors affecting diffuse cutaneous SSc subtype

Factors	Beta	p-value	OR (95% CI)
Age	-0.068	**0.002***	0.934 (0.895-0.976)
RF, positive	-1.187	0.103	0.305 (0.073-1.273)
Pulmonary involvement	3.434	**<0.001***	31.003 (7.736-124.25)
Constant	2.544	**0.029***	

Model is significant: chi-square =43.934; p<0.001; Nagelkerke R2=0.534. Limited cutaneous: reference category. *: Significant at 0.05 level according to Binary Logistic regression, OR: Odds ratio; CI: Confidence interval, SSc: Systemic sclerosis, RF: Rheumatoid factor

In a study conducted by Pandey et al. (17), with 50 SSc patients, the oesophagus was found to be dilated on HRCT in 58% of patients, and no age difference was observed between these patient groups. In a subsequent study involving 105 patients, the incidence of dilatation was found to be 62%, exhibiting a comparable trend. Furthermore, the study revealed that SSc subtypes, gender and serology were not associated with oesophageal dilatation (18). A further study, encompassing 54 SSc patients, revealed that oesophageal dilatation occurred in 69.2% of the subjects and was not associated with age (19). In contrast, the present study observed oesophageal dilatation in 56% of patients, consistent with existing literature. However, in contrast to the findings reported in the literature, it was observed that the mean age of patients with dilatation was higher than that of patients without dilatation. This may be attributable to the observation that progression is more prevalent in patients with advanced age of onset, as evidenced by other organ involvements, such as lung involvement. A more aggressive disease and increased organ involvement are typically observed in the diffuse cutaneous subtype when other laboratory characteristics are analysed. However, in this study, similar rates of oesophageal dilatation were observed in the limited and diffuse types. A similar observation was made in relation to ANA positivity titres and patterns. This finding may imply that oesophageal involvement is not determined by serology or subtype. However, further clarification is required through studies encompassing a larger number of patients.

DUs are a prevalent symptom in patients suffering from SSc, a condition in which vascular disease plays a pivotal role. These ulcers serve as indicators of not only the condition of the peripheral vascular bed but also the involvement of numerous organ systems. DUs have been observed to be associated with ILD, cardiac disease, and gastrointestinal involvement, particularly oesophageal involvement (20,21). It has been emphasized that esophageal motility disorder is observed, approximately 4.5 times more frequently in patients with DU (22). However, it should be noted that patients with esophageal symptoms (dysphagia, reflux) were evaluated in these studies. In the present study, it was observed that the prevalence of DUs was higher in the group with dilated oesophagus. However, this observation did not attain statistical significance. When ulcers were categorized as mild, moderate, and severe, similar findings were obtained in the two groups. Consistent with the findings of the present study, a lack of significant correlation was identified between the dilatation detected on HRCT and DU in the study by Vonk et al. (18). This finding suggests the possibility of etiopathogenetic factors other than vascular pathologies, playing a role in oesophageal dilatation.

A considerable number of studies have demonstrated a correlation between oesophageal dysfunction and the severity of ILD in SSc. Oesophageal dilatation is recognised as a risk factor for ILD progression. Moreover, studies have indicated that microaspiration of gastric content and GERD are associated with the onset and progression of ILD (23-25). In a study conducted by Salaffi et al. (26) with 126 SSc patients, the widest oesophageal dilatation was found to be 13.5 (±4.2) mm. It was emphasised that the severity of ILD increased as the oesophageal diameter increased on HRCT. Furthermore, a negative correlation was observed with DLCO.

Consequently, it has been emphasised that if the oesophagus is found dilated in patients with ILD in the early period of ILD diagnosis, it may be considered a risk factor, and early treatment may be initiated (26). In a further study of 270 SSc patients, the largest oesophageal diameter was found to be associated with more extensive radiographic ILD. In this study, the hypothesis that esophageal dysfunction increases with dilatation and leads to lung damage caused by aspiration of acid or gastric contents is defended, in accordance with other esophageal dilatation studies in the literature. It is thought that aspiration triggers the emergence of existing lung inflammation (27). In a study observing 75 early SSc patients over a period of one year, with the amount of oesophageal dilatation being measured concurrently, it was emphasised that worsening oesophageal diameter was a predictor of progression of lung fibrosis (28). In studies where oesophageal diameter and area were evaluated in conjunction, it was reported that both diameter and area were associated with the progression of ILD. However, the study did not ascertain whether pulmonary outcomes improved with symptomatic treatment (29,30). In the present study, it was established that oesophageal diameter was significantly larger in patients with pulmonary involvement and pulmonary hypertension. Consistent with the extant literature, the wider oesophageal diameter in patients with pulmonary involvement provides evidence to support the hypothesis that lung damage is caused by oesophageal dysfunction and aspiration of acid or gastric contents.

Study Limitations

The present study has some limitations. In this retrospective study, the lack of detailed data on lung involvement (FVC, DLCO, etc.) prevents the comparison of the level of involvement with oesophageal dilatation. Furthermore, the absence of parameters such as manometry, scintigraphy, or endoscopy for the evaluation of oesophageal dysfunction constitutes a significant limitation. The evaluation of oesophageal dilatation and progression of ILD with subsequent follow-up in this patient group is expected to provide valuable information. Finally, it is acknowledged that gastric pressure difference and medications (immunosuppressive and symptomatic treatment) may slightly change the oesophageal diameter during HRCT. A further limitation is the inability to compare oesophageal dilatation to the modified Rodman score, which significantly assesses skin fibrosis. Despite the study's limitations, it offers significant insights that will inform clinical practice and contribute to the existing body of literature.

CONCLUSION

HRCT performed to evaluate ILD, shows more esophageal dilatation than expected. HRCT particularly in newly diagnosed SSc patients, offers a valuable opportunity to assess the oesophagus. It offers numerous advantages over traditional methods, including cost-effectiveness and non-invasiveness. It is important to note that oesophageal diameter is associated with pulmonary involvement. Further studies are required to support the use of oesophageal diameter in HRCT evaluations as a parameter for patient follow-up.

Ethics

Ethics Committee Approval: Ethics committee approval for this retrospective study was obtained from the Süleyman Demirel University Faculty of Medicine Ethics Committee (approval number: 2024/83/25, dated: 05.11.2024).

Informed Consent: Retrospective study.

Footnotes

Authorship Contributions

Concept: A.D., Design: A.D., Data Collection or Processing: A.D., Z.U., Analysis or Interpretation: A.D., Z.U., Literature Search: A.D., Z.U., Writing: A.D.

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REFERENCES

1. Volkmann ER, Andréasson K, Smith V. Systemic sclerosis. Lancet. 2023;401:304-18.
2. Zampatti N, Garaiman A, Jordan S, et al. Performance of the UCLA Scleroderma Clinical Trials Consortium Gastrointestinal Tract 2.0 instrument as a clinical decision aid in the routine clinical care of patients with systemic sclerosis. Arthritis Res Ther. 2021;23:125.
3. Nassar M, Ghernautan V, Nso N, et al. Gastrointestinal involvement in systemic sclerosis: An updated review. Medicine (Baltimore). 2022;101:e31780.
4. Volkmann ER, McMahan Z. Gastrointestinal involvement in systemic sclerosis: pathogenesis, assessment and treatment. Curr Opin Rheumatol. 2022;34:328-36.
5. Roberts CG, Hummers LK, Ravich WJ, Wigley FM, Hutchins GM. A case-control study of the pathology of oesophageal disease in systemic sclerosis (scleroderma). Gut. 2006;55:1697-703.
6. Amaral TN, Peres FA, Lapa AT, Marques-Neto JF, Appenzeller S. Neurologic involvement in scleroderma: a systematic review. Semin Arthritis Rheum. 2013;43:335-47.
7. Bautista-Sanchez R, Khanna D. Systemic sclerosis-associated interstitial lung disease: How to manage in 2024? Rheumatol Immunol Res. 2024;5:157-65.
8. Rahaghi FF, Hsu VM, Kaner RJ, et al. Expert consensus on the management of systemic sclerosis-associated interstitial lung disease. Respir Res. 2023;24:6.
9. Perelas A, Silver RM, Arrossi AV, Highland KB. Systemic sclerosis-associated interstitial lung disease. Lancet Respir Med. 2020;8:304-20.
10. Winstone TA, Hague CJ, Soon J, et al. Oesophageal diameter is associated with severity but not progression of systemic sclerosis-associated interstitial lung disease. Respirology. 2018;23:921-6.
11. van den Hoogen F, Khanna D, Fransen J, et al. 2013 classification criteria for systemic sclerosis: an American College of Rheumatology/European League Against Rheumatism Collaborative Initiative. 2013;72:1747-55.
12. LeRoy EC, Medsger TA Jr. Criteria for the classification of early systemic sclerosis. J Rheumatol. 2001;28:1573-6.
13. Cappelli L, Wigley FM. Management of Raynaud phenomenon and digital ulcers in scleroderma. Rheum Dis Clin N Am. 2015;41:419–38.
14. Morrisroe K, Stevens W, Sahhar J, et al. Digital ulcers in systemic sclerosis: their epidemiology, clinical characteristics, and associated clinical and economic burden. Arthritis Res Ther. 2019;21:299.
15. Simonneaul G, Montani D, Celermajer DS, et al. Haemodynamic definitions and updated clinical classification of pulmonary hypertension. Eur Respir J. 2019;53:1801913.
16. Pitrez EH, Bredemeier M, Xavier RM, et al. Oesophageal dysmotility in systemic sclerosis: comparison of HRCT and scintigraphy. Br J Radiol. 2006;79:719-24.
17. Pandey AK, Wilcox P, Mayo JR, et al. Oesophageal dilatation on high-resolution CT chest in systemic sclerosis: what does it signify? J Med Imaging Radiat Oncol. 2011;55:551-5.
18. Vonk MC, van Die CE, Snoeren MM, et al. Oesophageal dilatation on high-resolution computed tomography scan of the lungs as a sign of scleroderma. Ann Rheum Dis. 2008;67:1317-21.
19. Karamanolis GP, Denaxas K, Panopoulos S, et al. Severe oesophageal disease and its associations with systemic sclerosis. Clin Exp Rheumatol. 2017;35:82-5.
20. Hughes M, Herrick AL. Digital ulcers in systemic sclerosis. Rheumatology (Oxford). 2017;56:14-25.
21. Sunderkötter C, Herrgott I, Brückner C, et al. Comparison of patients with and without digital ulcers in systemic sclerosis: detection of possible risk factors. Br J Dermatol. 2009;160:835-43.
22. Xu D, Li MT, Hou Y, et al. Clinical characteristics of systemic sclerosis patients with digital ulcers in China. Clin Exp Rheumatol. 2013;31:46-9.
23. Tobin RW, Pope CE 2nd, Pellegrini CA, Emond MJ, Sillery J, Raghu G. Increased prevalence of gastroesophageal reflux in patients with idiopathic pulmonary fibrosis. Am J Respir Crit Care Med. 1998;158:1804-8.
24. Hoppo T, Komatsu Y, Jobe BA. Gastroesophageal reflux disease and patterns of reflux in patients with idiopathic pulmonary fibrosis using hypopharyngeal multichannel intraluminal impedance. Dis Esophagus. 2014;27:530-7.
25. Ruaro B, Pozzan R, Confalonieri P, et al. Gastroesophageal reflux disease in idiopathic pulmonary fibrosis: Viewer or actor? To treat or not to treat? Pharmaceuticals (Basel). 2022;15:1033.
26. Salaffi F, Di Carlo M, Carotti M, Fraticelli P, Gabrielli A, Giovagnoni A. Relationship between interstitial lung disease and oesophageal dilatation on chest high-resolution computed tomography in patients with systemic sclerosis: a cross-sectional study. Radiol Med. 2018;123:655-63.
27. Richardson C, Agrawal R, Lee J, et al. Esophageal dilatation and interstitial lung disease in systemic sclerosis: A cross-sectional study. Semin Arthritis Rheum. 2016;46:109-14.
28. Wangkaew S, Losuriya P, Euathrongchit J. Worsening of esophageal dilatation is associated with increase in a high-resolution computed tomography (HRCT) score in early systemic sclerosis-associated interstitial lung disease (SSc-ILD). Clin Rheumatol. 2021;40:955-63.
29. Volkmann ER, Tashkin DP, Leng M, Kim GHJ, Goldin J, Roth MD. Association of symptoms of gastroesophageal reflux, esophageal dilation, and progression of systemic sclerosis-related interstitial lung disease. Arthritis Care Res (Hoboken). 2023;75:1690-7.
30. Figueiredo AFSD, Costa JF, Matos AP, Ramalho M. Esophageal dilatation as a predictor of systemic sclerosis in patients with interstitial lung disease. Turk Thorac J. 2021;22:231-6.