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Nailfold capillaroscopic pattern and modified Rodnan skin score associated with deterioration of right ventricle functions in systemic sclerosis patients without overt pulmonary hypertension

Aşikâr pulmoner hipertansiyonu olmayan sistemik sklerozlu hastalarda tırnak kapilaroskopi bulguları ve modifiye Rodnan skoru sağ ventrikül fonksiyonlarında bozulma ile ilişkilidir

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ABSTRACT

Objective: Although nailfold capillaroscopy (NC) and modified Rodnan skin score (mRSS) have already been studied in a variety of contexts related to Systemic Sclerosis (SSc) progression, there is limited data about the relationships between NC, mRSS, and right ventricle (RV) function in SSc patients without overt pulmonary arterial hypertension (PAH). In this study, we examined the relationship between RV function and clinical SSc parameters such as NC pattern and mRSS.

Material and Method: Thirty two patients with SSc and twenty healthy participants as a control group were enrolled in this study. Patients with SSc were assessed for digital ulcers, Raynaud's phenomenon, and severity of skin involvement by a rheumatology specialist. Also, all participants underwent echocardiographic examinations by cardiology specialists. The echo parameters were measured considering the criteria of the American Society of Echocardiography guidelines.

Results: Systolic pulmonary arterial pressure (sPAP) was statistically higher in the SSc group (26.4±3.2 vs 30.8±3.6 mmHg, p<0.001). Tricuspid annular plane systolic movement (TAPSE), pulmonary accerelation time and mean RV free wall strain were found to be lower in the SSc group (p=0.003, p<0.001, p<0.001 for all). Patients with capillaroscopic active and late pattern and late pattern had significantly lower TAPSE, ventricular isovolumic acceleration (IVA) and RV free wall mean strain (p=0.002, p=0.005, and p<0.001, respectively) compared to patients with capillaroscopic early pattern and active and early pattern In the univariant linear regression analisys, in the SSc group, mRSS was significantly associated with RV free wall mean strain (R2=0.192; p=0.007).

Conclusion: In this study, early deterioration of sPAP and RV functions were shown in SSc patients without overt PAH. Also, high scores of mRSS and abnormal capilloroscopic pattern were associated with worse RV function.

Keywords: Systemic sclerosis, nailfold capillaroscopy, modified Rodnan skin score, right ventricle strain imaging

ÖZ

Amaç: Tırnak kapilloskopisi ve modifiye Rodnan skoru sistemik sklerozda (SS) çeşitli durumlarda klinik progresyon ile ilişkili bulunmuş olmasına rağmen sağ ventrikül fonksiyonları ile ilişkileri yeterince çalışılmamıştır. Bu çalışmada aşikar pulmoner hipertansiyonu olmayan sistemik sklerozlu hastalarda sağ ventrikül fonksiyonları ile modifiye Rodnan skoru, tırnak kapillaroskopisi gibi klinik SS klinik parametreleri ile arasındaki ilişki araştırılmıştır.

Gereç ve Yöntem: Otuz iki SS'li hasta ve yirmi sağlıklı birey kontrol grubu için çalışmaya alınmıştır. Hastalar romatoloji uzmanı tarafından dijital ülserler, tırnak kapillaroskopisi ve deri tutulumu için değerlendirilmiştir. Tüm katılımcılara ekokardiyografik değerlendirme kardiyoloji uzmanı tarafından yapılmıştır. Ekokardiyografik parametreler Amerikan Ekokardiyografi Birliğinin kılavuzlarına göre hesaplanmıştır.

Bulgular: Sistolik pulmoner arteriyel SS grubunda istatiksel olarak anlamlı şekilde yüksekti (26,4±3,2 vs 30,8±3,6 mmHg, p=0,001). Triküspit anüler plan sistolik hareketi (TAPSE), pulmoner akselerasyon zamanı ve ortalama sağ ventrikül strain değeri SS grubunda anlamlı olarak daha düşüktü (p=0,003, p=0,001, p=0,001). Kapillaroskopik olarak aktif ve geç patern ve geç paterne sahip hastalarda erken ve aktif paterne ve erken paterne sahip hastalara göre TAPSE, ventriküler isovolumik akselerasyon ve sağ ventrikül ortalama serbest duvar straini anlamlı olarak daha düşüktü (p=0,002, p=0,005, and p=0,001, sırasıyla) Univariat doğrusal regresyon analizde, SS grubunda modifiye Rodnan cilt skoru ile sağ ventrikül serbest duvar ortalama strain arasında anlamlı ilişki vardı (R2=0,192; p=0,007).

Sonuç: Bu çalışmada SS'li hastalarda sistolik pulmoner arteriyel basınçta ve sağ ventrikül fonksiyonlarında erken dönemde bozulma olduğu gösterilmiştir. Ayrıca yüksek modifiye Rodnan cilt skoru ve geç dönem kapillaroskopik değişikliklerin sağ ventrikül fonksiyonlarındaki bozulmayla ilişkili olduğu bulunmuştur.

Anahtar Kelimeler: Sistemik skleroz, tırnak kapillaroskopi, modifiye Rodnan cilt skoru, sağ ventrikül strain görüntüleme

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INTRODUCTION

Systemic sclerosis (SSc) is an immunologic illness caused by fibroblast and endothelial cell dysfunction that results in excessive collagen production. Skin tightening and thickening is a hallmark of SSc. Two types of SSc are described as limited cutaneous (lcSSc) and diffuse cutaneous (dcSSc) SSc according to skin involvement. It was reported that extensive and early skin involvement is linked with poor prognosis (1,2).

Pulmonary arterial hypertension (PAH), myocardial dysfunction, conduction abnormalities, pericardial effusion, and myocardial ischemia are consequences of the cardiovascular (CV) involvement of SSc. PAH is considered as the most important CV involvement observed in SSc. Patients with SSc and PAH have a three-fold increased risk of mortality compared to patients without SSc (3). Patients with SSc should be closely monitored for PAH because it is one of the major cause of death.

Right ventricle (RV) 2-D strain imaging in echocardiography gives detailed information about ventricle function and prognosis of PAH (4,5). Strain imaging shows deterioration of myocardial function more sensitively than conventional echocardiographic parameters. Also, 2-D strain imaging gives quantitative values and helps to overcome observer dependent errors. Decreases in RV free wall strain values in PAH are associated with poor prognosis.

Nailfold capillaroscopy (NC) shows microvascular damage in SSc and is useful for detecting early disease. It is also non-invasive and gives valuable data for diagnosis of SSc (6). Because many studies have shown that NC correlates with visceral involvement in SSC, nowadays, NC has been used as a proxy marker for disease of SSc activity (7,8). The modified Rodnan skin score (mRSS), a standardized method for assessing thicknessof the skin, was used in SSc clinical trials (9,10). Previous studies have shown mRSS to be corelated with some adverse cardiac and pulmonary parameters (9). Although NC and mRSS were studied in many circumstances associated with SSc progression, limited data exists about the relations of RV function with NC and mRSS in patients without overt PAH.

In this study, we examined RV function, which was assessed with strain imaging in echocardiography, in patients with SSc who did not show overt PAH. We compared echocardiographic RV functions of patients with SSc and healthy controls. We aimed to find out the associations between mRSS, NC pattern and RV functions.

MATERIAL AND METHOD

The study was carried out with the permission of Kayseri City Hospital Ethics Committee (Date: 25.06.2020, Decision No: 2020/97). The written consents were obtained from the patients. The study complied with the ethical principles of Helsinki Declaration.

Thirty two patients with SSc, being followed in the rheumatology and cardiology clinics and twenty healthy controls were included in the study. The study's data collection was done in the period from May 1, 2020 to April 1, 2021.

2013 American College of Rheumatology (ACR)/ European League Against Rheumatism (EULAR) classification criteria for SSc) were used to classify as SSc. The entire population's sociodemographic characteristics, such as age, sex, body mass index, and smoking habits, were recorded. A rheumatology specialist examined all patients for digital ulcers, Raynaud's phenomenon, as well as the severity of skin involvement. The standard method defined in Khanna D's study was used to calculate mRss for each patient (11). LeRoy and Medsger's classification criteria were also used to categorize dcSSc and lcSSc (12).

Patients with overlapping syndromes with SSc such as rheumatoid arthritis, and also patients with any other chronic disease were excluded.

NC was carried out using a videocapilleroscopy at magnifications 200x. The NCs were categorized into four groups based on the following criteria:

1. Dimensions, shape, and density greater than 7 mm are considered normal (early pattern).
2. An early pattern with large size, density greater than 7 mm, and the presence or absence of haemorrhages (active and early pattern).
3. Active pattern; lower density (4-6 mm), patchy giant pattern, capillary absence, and some abnormal shapes (active and late pattern).
4. Late pattern; low density (3mm), frequent abnormal shapes, but no giant capillaries (late pattern) (13).

Echocardiography

All participants underwent echocardiographic examinations by a cardiology specialist. All measurements were performed with Philips Epic 7 (Philips, Amsterdam, Netherlands) echocardiography machine and X5-1 TTE probes. Left lateral position and apical 2 and 4 cavity images were obtained from the parasternal short and long axes. M-mode was used to measure the left ventricular (LV) end-sistolic and end-diastolic diameters from the parasternal long axis (at the mitral chordal level perpendicular to the long axis of the ventricle). Posterior and interventricular septal wall diastolic diamater, internal dimension of the LV, left atrial area, peak A and E waves of mitral inflow, and lateral and septal peak E' of the mitral annulus were all assessed.

Right Ventricle Functions

The echo parameters were measured considering the American Society of Echocardiography's guidelines (14). The tricuspid valve annulus level is used to calculate the RV free wall's tissue Doppler imaging value. A', E' and

S' waves were asssessed, and the E/A and E/ E' ratios were computed. Tricuspid annular plane systolic movement (TAPSE) was measured in an apical four-chamber view of the lateral tricuspid annulus using M-mode imaging. The systolic pulmonary arterial pressure (sPAP) was calculated using continuous wave Doppler by adding the estimated right atrial pressure and the pressure value of Bernoulli's equation of tricuspidal regurgitation jet velocity. Also, pulmonary valve stenosis was excluded (14).

Isovolumetric contraction velocity (IVV) divided by acceleration time (AT) yielded right ventricular isovolumic acceleration (IVA). IVV was defined as the peak myocardial speed during isovolumic contraction from the lateral tricuspid annulus. The time it takes to reach top speed is referred to as "AT" (14)

The RV end-diastolic area (RVADA) and RV end-systolic area (RVASA) were assessed from an apical 4-chamber view. The RV-fractional area change (RVFAC) was calculated as follows: RVFAC (percentage)=RVADA-RVASA/RVADA x 100.

Using the Philips QLAB 9.0 program, speckle tracking analysis of the RV was acquired from the apical four-chamber view images. At the end of systole, the endocardial border of the RV free wall was drawn manually and changed automatically to comprise the complete myocardium. To adjust the thickness of the myocardium, the physician manually changed the region of interest. The RV longitudinal strain was estimated as the average of the three segments recorded in the basal, mid-ventricular, and apical segments of the RV free wall. The fraction of myocardial shortening relative to the baseline length is referred to as longitudinal strain. Their values are negative, and lower strain values show more shortening.

Statistical Analysis

The data was analyzed using the IBM SPSS Statistics 21.0. The mean and standard deviation are used to express continuous variables. To determine the normality of a continuous variable's distribution, the Kolmogorov-Smirnov and Shapiro-Wilk tests were used. To compare continuous variables between groups, the Mann-Whitney U test or the Student's t test were used. The Chi-square test was also used to analyze categorical variables. Univariate linear regression analysis was used for demostarating the association between RV free wall mean strain to mRSS, duration to first symptom and duration to first diagnosis As statistically significant, $p<0.05$ values were accepted.

RESULTS

The characteristics of the participants were shown in **Table 1**. There was no difference in terms of age between the SSc and healthy controls (51.6±11.3, 47.9±7.4, p=0.137 respectively). BMI was similar in groups (27.5±4.6, 25.3±4.1, p=0.062). Heart rate, systolic and diastolic blood pressure were statistically similar in the SSc and healthy controls (p=0.564, p=0.649 and p=0.398 respectively). CRP and WBC levels were found to be higher in the SSc group (p=0.020 and P=0.007). AST, ALT, Hgb and Plt levels were similar in two groups (p=0.920, p=0.918, p=0.115 and p=0.733, respectively).

Table 1. Clinical characteristics of the participants

	Systemic sclerosis patients (n=32)	Control group (n=20)	p value
Age	51.6±11.3	47.9±7.4	0.137
Female sex	27 (%84)	11 (%55)	0.318
BMI (kg/m2)	27.5±4.6	25.3±4.1	0.102
Crp (mg/dl)	4.24±4.27	1.79±2.02	**0.020**
AST (mg/dl)	19.9±7.1	20.1±6.1	0.920
ALT (mg/dl)	18.3±11.1	16.3±6.5	0.918
WBC $\times 10^9$/L	7306±1813	5908±1660	**0.007**
HGB (gr/dl)	13.3±1.5	13.9±1.2	0.115
PLT $\times 10^9$/L	285600±75085	277200±102503	0.733
Systolic blood pressure, (mmHg)	122.6±14.7	120.8±12.1	0.649
Diastolic blood pressure, (mmHg)	75.9±6.5	74.9±7.0	0.398
Heart rate (beats/min)	72.75±7.5	74.9 ±9.0	0.564
Limited cutaneous systemic sclerosis, n, %	16, %50		
Modified rodnan score	15.1±11.0		
Capillaroscopic pattern 1	10 (%31.2)		
Capillaroscopic pattern 2	9 (%28.1)		
Capillaroscopic pattern 3	2 (% 6.2)		
Capillaroscopic pattern 4	11 (% 34.3)		
Severity index of raynoud phenome	4.38±2.21		
Duration to first diagnosis, (year)	5.0±4.26		
Duration to first complain, (year)	12.0±10.2		

BMI: Body mass index, Crp: C reactive protein, AST: aspartate aminotransferase, ALT: alanine aminotransferase,WBC: White blood cells, PLT: platelet

Half of the SSc patients were limited cutaneous systemic sclerosis type. The mean mRSS was 15.1±11.0. Numbers of patients according to capilloroscopic pattern 1, 2, 3 and 4 were 10, 9, 2 and 11, respectively. The Raynaud phenomen was first seen at the age of 40.9±14.0 and the severity index of the Raynaud phenomen was 3.96±1.89. The mean duration to diagnosis of SSc was 12.0±10.2 years ago and the mean duration to first symptom was 5.0±4.26 years ago.

Table 2 shows the echocardiographic parameters of the patients with SSc and healthy controls. LV structural and functional parameters were not statistically different in the two groups. sPAP was statistically higher in the SSc group (26.4±3.2 vs 30.8±3.6 mmHg, p=0.001). TAPSE and AT were found to be lower in the SSc group (p=0.003). IVA and IVV were significantly higher in healthy controls (p<0,001 for all). The E/A ratio was higher in the SSc group but not statistically significant (p=0.149). The SSc group had statistically significant lower basal S', RV free wall basal strain, RV free wall apical strain and RV free wall mean strain values (p=0.019, p=0.023, P<0.001and P<0.001, respectively). **Figure 1** shows that strain value of RV free wall segments and RV free wall mean strain in the groups. RVEDA and RVESA were found higher in the SSc group but not statisically significant (p=0.057, p=0.053, respectively). RVFAC was lower in the SSc group but not statistically significant (p=0.279).

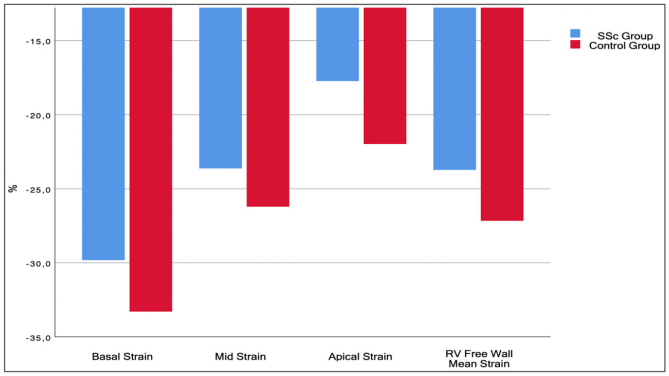

Figure 1. Strain value of right ventricle free wall segments and right ventricle free wall mean strain in the groups. RV: Right ventricle

Table 2. Comparision of echocardiographic parameters between groups

	Systemic sclerosis patients	Control group	p value
LV structure and function function			
End-diastolic diameter (mm)	4.37±0.66	4.41±0.33	0.824
End- systolic diameter (mm)	2.92± 0.59	2.88±0.30	0.768
IVSD (mm)	0.99±0.10	1.0±0.09	0.460
PWD (mm)	0.92±0.09	0.97±0.88	0.069
LVEF, %	66.8±5.1	67.2±6.0	0.534
Mitral E wave, (cm/s)	0.68±0.11	0.66±0.12	0.583
Mitral A wave (cm/s)	0.56±0.10	0.54±0.09	0.622
E/A	1.27±0.34	1.25±0.29	0.827
Deceralation time, (msec)	163.6±20.5	171.3±17.7	0.173
Tissue Doppler velocities			
E' wave (cm/s)	10.9±2.04	11.3±2.32	0.488
A' wave (cm/s)	8.46±2.35	9.00±1.07	0.344
S' wave (cm/s)	13.3±2.61	14.5±2.37	0.131
E/E'	6.36±0.95	6.03±1.32	0.290
RV Structure and Function			
sPAP (mmHg)	30.8±3.67	26.4±3.2	**< 0.001**
TAPSE (mm)	2.52±0.21	2.71±0.20	**0.003**
Pulmonary accerelation time (msec)	106.1±13.4	120.1±10.0	**< 0.001**
IVA (m/sec2)	3.29±0.80	4.34±0.68	**< 0.001**
IVV (m/sec)	12.49±2.40	14.93±2.07	**< 0.001**
AT (msec)	38.75±5.86	34.6±3.71	**0.007**
Tricuspid E wave (cm/s)	0.65±0.14	0.55±0.08	**0.014**
Tricuspid A wave (cm/s)	0.48±0.10	0.46±0.10	0.476
E/A	1.36±0.27	1.24±0.28	0.149
Decerelation time (msec)	157.2 ±43.9	166.6±28.2	0.401
Basal S' (cm/sec)	12.5±3.27	14.9±2.29	**0.019**
Basal strain, %	-29.8±6.00	-33.2±3.47	**0.023**
Mid strain, %	-23.6±5.33	-26.2±2.77	0.051
Apical strain, %	-17.7±4.58	-21.9±2.80	**< 0.001**
RV free wall mean strain, %	-23.7±3.83	-27.1±1.70	**< 0.001**
RVADA mm2	25.3±6.98	22.0±3.56	0.057
RVASA mm2	13.8±5.17	11.3±2.29	0.053
RVFAC, %	46.2±7.99	48.4±4.77	0.279

LV left ventricle, IVSD: intraventricular septum diameter, PWD: posterior wall diameter, LVEF: left ventricular ejection fraction, RV: right ventricle, sPAP: systolic pulmonary artery pressure, TAPSE: Tricuspid annular plane systolic movement, IVA: isovolumic acceleration, IVV: isovolumic velocity, RVADA: right ventricle end-diastolic area, RVASA: Right ventricle end-systolic area, RVFAC: Right ventricle fractional area change.

SSc patients were divided into two groups considering the capillaroscopic pattern 1,2 (SSc-1) and capillaroscopic pattern 3,4 (SSc-2). **Table 3** show comparision of systolic pulmonary artery pressure and right ventricle function between SSc-1 and SSc-2 groups. sPAP is significantly higher in the SSc-1 group than in the SSc-2 group (32.5±3.1 , 29.6±3.6 , p=0.025). The SSc-1 group had significantly higher TAPSE, IVA, and RV free wall mean strain (p=0.002, p=0.005, and p<0.001, respectively) compared to the SSc-2 group. **Figure 2** show RV free wall mean strain values according to capilloroscopic patterns. There was no statisically difference in terms of RVEDA, RVESA and RVFAC between SSc-1 and SSc-2.

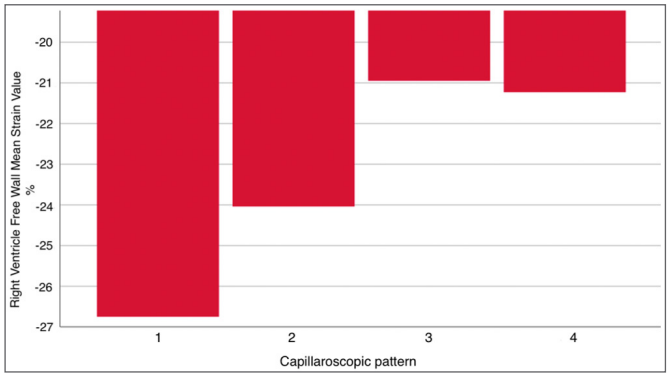

Figure 2. Right ventricle free wall mean strain values according to capilloroscopic patterns

Table 3. Comparision of systolic pulmonary artery pressure and right ventricle function between SSc-1 and SSc-2 groups

	SSc-1 (capillaroscopic pattern:1,2) n: 19	SSc-2 (capillaroscopic pattern:3,4) n:13	p values
sPAP (mmHg)	29.6±3.6	32.5±3.1	**0.025**
TAPSE	2.61±0.19	2.39±0.15	**0.002**
IVA	3.61±0.72	2.83±0.71	**0.005**
RV free wall mean strain, %	-25.4±3.66	-21.1±2.45	**< 0.001**
RVEDA	24.7±6.7	26.1±7.5	0.577
RVESA	13.1±5.2	14.7±5.1	0.426
RVFAC	47.7±8.5	44.1±6.9	0.222

RV: right ventricle, sPAP: systolic pulmonary artery pressure, TAPSE: Tricuspid annular plane systolic movement, IVA: isovolumic acceleration , RVADA: right ventricle end-diastolic area, RVASA: Right ventricle end-systolic area, RVFAC: Right ventricle fractional area change.

In the SSc group, the results of univariant linear regression analysis demostrating the association of mRSS, duration to first diagnosis, duration to first complain and type of SSc with RV free wall mean strain are shown in **Table 4**. In the SSc group, mRSS was significantly associated with RV free wall mean strain (p=0.007, respectively). Duration to first symptom, duration to first diagnosis and type of SSc were not associated with RV free wall strain. (p=0.053, p=0.099 and p=0.703)

Table 4. Univariate linear regression analysis demonstrating the association of RV mean free wall strain

	β	SE	95% CL	Adjusted R2	p
mRSS	0.163	0.056	0.048 to 0.278	0.192	0.007
Duration to first symptom	0.129	0.064	-0.002 to 0.259	0.090	0.053
Duration to first diagnosis	0.267	0.157	-0.053 to 0.587	0.058	0.099
SSc type	0.533	1.385	-2.296 to 3.361	-0.028	0.703

mRSS: modified Rodnan skin score, SSc: systemic sclerosis

DISCUSSION

In this study, three main findings were listed as: firstly, SSc patients have larger RV sizes, poorer RV function, and higher sPAP levels than the control group, 2. These outcomes are associated with mRSS, 3. Patients with capillaroscopic patterns 3 and 4 had higher sPAP and poorer RV function.

In SSc patients, the presence of PAH and RV dysfunction is associated with a poor prognosis. Determining clinical and echocardiographic predictors of PAH and RV dysfunction in SSc patients is critical for early diagnosis and treatment. According to the ESC guidelines, > 25 mmHg mean PAP with right heart catheterization is accepted as PAH (15). But the pathophysiologic changes occurred before the development of the 25 mmHg mean PAP (16). In SSc patients, late diagnosis PAH had a worse prognosis (17). So, early treatment and early diagnosis of vulnerable SSc patients for PAH is important for improving the prognosis of patients with SSc.

Some echocardiographic imaging techniques and calculations are used for early determination of deterioration of RV functions. In this study, we evaluated tissue Doppler imaging, RV free wall strain imaging, IVV, and IVA. They are valuable markers for the assessment of RV systolic function. IVV reflects RV contractility, which is assessed invasively (18). Also, IVV was found to be a marker for predicting poor prognosis in PAH (19). In this study, IVV and IVA were lower in SSc patients. So, it could be considered that RV systolic deterioration begins before the beginning of overt PAH.

In this study, RV sizes were higher in the SSc group. Bratis et al. (20) found lower RV sizes in asymptomatic SSc patients. They considered that lower RV sizes were associated with higher heart rates. In our study, the heart rates of the two groups were not different. Because echocardiographic parameters were not established in Bratis K's study, real sPAP values were not known. In our study, however, sPAP values were in the normal range, but they were higher in the SSc group. Higher sPAP and similar heart rate could be reasons for the higher RV volumes compared to the control group. Also, these factors may explain the different results compared to Bratis K's findings.

Strain values give crucial data about systolic function of the myocardium, prognosis and disease severity in many conditions such as SLE, PAH, sarcoidosis, and SSc (21,22). Deterioration of strain can be used as an early predictor for some diseases' cardiac involvement (21,22). Kusunose et al. (23) showed that decreasing strain in sarcoidosis patients without cardiac involvement is associated with adverse effects of sarcoidosis. In our study, we found a reduction in RV free wall strain in SSc patients. Also, this deterioration was associated with sPAP. Although in our study, we excluded patients with over sPAP 40 mmHg, slightly elevated sPAP could be important for SSc patients.

The mRSS was shown to predict disease severity, activity and mortality (24). Clements et al. (25) mRSS was associated with heart involvement. But they did not define heart involvement in detail. So, the relationship between PAH, RV function echo parameters, and mRSS has not been studied adequately previously. In our study, mRSS was associated with sPAP, TAPSE, IVV, IVA, and the global RV strains RVEDA, RVESA, and RVFAC. These data show that fibrotic process deposition occurs together with the skin and the heart. However, skin thickness begins to increase after the initial disease, and with the progression of SSc skin thickness can vary. Sometimes skin thickness progresses to a peak, then regresses or slowly continues to progress. We can consider that the intermediate age of disease is accompanied by thick skin. Because we excluded patients with over 40 mmHg sPAP, mRSS can be a good parameter for predicting RV function and sPAP for SSc patients without overt PAH.

NC is a noninvasive method which is a useful tool for distinguishing the etiology of raynoud phenomena, whether secondary to SSc or not. Morphologic changes in nailfold associated with organ involvement. Riccieri et al. (26) reported a link between mean PAP and NC score. In our study, even though patients had no overt PAH, severe capillaroscopic pattern could predict higher sPAP and worse RV function.

SSc is classically divided into two groups: diffuse and limited cutaneous SSc. However, the diffuse cutaneous type is accompanied by more organ involvement (interstitial lung disease, gastrointestinal diseases, or renal disease). PAH has the same incidence in diffuse cutaneous and limited cutaneous types. In our study, we did not find differences in sPAP, RV volumes and functions in two groups. Also, the correlation of sPAP and mRSS, capillaroscopic pattern continued. A high mRSS score and capillorscopic pattern 3, 4 may indicate a high risk of PAH development.

This study has several limitations. PAP values and RV functions were measured by using echocardiography. Invasive measurement of PAP can give more reliable data. Cardiac MR gives detailed information about the function and sclerosis of the RV. A relatively small sample size is another limitation. The study designed with a larger sample size may help to understand how PAP and RV function do change in SSC patients without overt PAH.

CONCLUSION

In this study, we demonstrated that early deterioration of sPAP and RV functions in SSc patients without overt PAH. Also, high scores of mRSS and abnormal capilloroscopic pattern were associated with worse RV function.

ETHICAL DECLARATIONS

Ethics Committee Approval: The study was carried out with the permission of Kayseri City Hospital Ethics Committee (Date: 25.06.2020, Decision No: 2020/97).

Informed Consent: All patients signed the free and informed consent form.

Referee Evaluation Process: Externally peer-reviewed.

Conflict of Interest Statement: The authors have no conflicts of interest to declare.

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Author Contributions: All of the authors declare that they have all participated in the design, execution, and analysis of the paper and that they have approved the final version.

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