Z Rheumatol 2019 · 78:287–294
https://doi.org/10.1007/s00393-018-0555-x
Published online: 15 October 2018

Redaktion
U. Müller-Ladner, Bad Nauheim
U. Lange, Bad Nauheim

Shi-Min Yuan

Department of Cardiothoracic Surgery, The First Hospital of Putian, Teaching Hospital, Fujian Medical University, Putian, China

Aortic aneurysm and dissection in systemic lupus erythematosus

Introduction

Systemic lupus erythematosus (SLE) is a chronic autoimmune disease affecting the blood vessels and connective tissues, causing damage to the skin, joints, and organs. The cardiovascular involvements of SLE are often present with pericarditis and sometimes with coronary arteritis [1]. However, aortic aneurysm formation and aortic dissection are rarely seen in SLE patients [2]. SLE patients have been found to be at a significantly increased risk of developing aortic aneurysm and dissection in comparison to non-SLE controls, and the incidence of aortic aneurysm in SLE patients is significantly higher than that of the non-SLE controls [3]. Wang et al. [4] reported in a retrospective study of 15,209 SLE patients that 20 (0.13%) patients had aortic aneurysms and 13 (0.09%) patients developed aortic dissection. Choudhary et al. [5] reported an 11.5% incidence of unruptured aneurysms in a setting of 104 SLE patients. The incidence, etiology, risk factors, and outcomes of aortic aneurysm and dissection in SLE patients were largely unknown. The present article aims to highlight the clinical features of this patient setting.

Methods

PubMed was searched for publications reporting aortic aneurysm or dissection due to SLE published between 2000 and 2017. The search terms included "systemic lupus erythematosus", "aortic aneurysm", "aortic dissection", and "aortic dilatation". Bibliographic references were tracked for ensuring the completion of literature retrieval.

Data were carefully extracted for study population, demographics, diagnostic techniques, clinical features of aortic aneurysm or dissection in SLE patients, associated disorders, treatment, follow-up length, and patients' outcomes, etc.

Quantitative data were presented as mean ± standard deviation with range and median values, and were compared by using the independent *t*-test. The frequencies were compared by Fisher's exact

Table 1 51 associated conditions in 26 patients

Associated condition	*n* (%)	Reference
Hypertension	9 (17.6)	[2, 8, 11, 13, 17, 18, 29, 37]
Chronic renal failure	9 (17.6)	[11, 16, 18, 22, 27, 29, 32, 33, 39]
Hemodialysis	8 (15.7)	[9, 11, 14, 16, 18, 22, 29, 39]
Aortic valve regurgitation	4 (7.8)	[7, 8, 26, 32]
Libman–Sacks endocarditis	3 (5.9)	[7, 9, 12]
Ankylosing spondylitis	1 (2.0)	[17]
Antiphospholipid antibody syndrome	1 (2.0)	[34]
Bicuspid aortic valve	1 (2.0)	[17]
Chronic heart failure	1 (2.0)	[26]
Descending aortic dissection recurrence	1 (2.0)	[25]
Goodpasture syndrome	1 (2.0)	[30]
Intracranial hemorrhage	1 (2.0)	[2]
Lupus nephritis	1 (2.0)	[14]
Occluded celiac artery	1 (2.0)	[6]
Occluded left anterior descending coronary artery and popliteal artery along with infarction of the right kidney	1 (2.0)	[34]
Ortner's syndrome	1 (2.0)	[27]
Patent ductus arteriosus	1 (2.0)	[27]
Pleural effusions	1 (2.0)	[20]
Right subclavian artery arising from the proximal descending aorta	1 (2.0)	[22]
s/p ascending aorta replacement	1 (2.0)	[21]
s/p coronary artery stenosis, s/p coronary artery bypass grafting	1 (2.0)	[28]
Sjögren syndrome	1 (2.0)	[25]
Wegner disease	1 (2.0)	[30]

s/p status post

Table 2 A comparison of patient information of patients with aortic aneurysm and aortic dilation

Variable	Aortic aneurysm ($n = 27$)	Aortic dissection ($n = 13$)	χ^2 (t)	p value
Gender (m/f)	8/19	2/9	0.528	0.690
Age (years)	47.0 ± 17.5 (range, 9–76; median, 47; $n = 27$)	38.1 ± 15.6 (range, 17–62; median, 42; $n = 11$)	–1.458	0.153
SLE history (years)	17.7 ± 12.0 (range, 2–38; median, 15.5; $n = 14$)	8.3 ± 7.5 (range, 0–20; median, 7; $n = 7$)	–1.892	0.074
History of steroids (years)	14.5 ± 9.2 (range, 0.75–32; median, 14; $n = 17$)	10.1 ± 6.7 (range, 0.58–20; median, 9; $n = 6$)	1.060	0.301
Symptoms (n)				
Asymptomatic	3/22	0/9	1.359	0.537
Pain (abdomen, back, chest)	8/21	9/9	9.832	0.003
Dyspnea	4/21	1/9	0.286	1.000
Pulsatile mass	2/21	0/9	0.918	1.000
Cough	2/21	1/9	0.018	1.000
Fever	2/21	2/9	0.879	0.348
Edema	1/21	1/9	0.408	0.523
Presyncope	1/21	0/9	0.443	1.000
Palpitation	1/21	0/9	0.443	1.000
Chest tightness	1/21	0/9	0.443	1.000
Hoarseness	1/21	0/9	0.443	1.000
Dysphasia	1/21	0/9	0.443	1.000
Numbness	0/21	1/9	2.414	0.300
Dizziness	0/21	1/9	2.414	0.300
Weakness	0/21	1/9	2.414	0.300

Table 3 Locations of the aortic aneurysm/dissection by incorporating the 2 patients with concurrent aortic aneurysm and dissection, n (%)

Location	Aortic aneurysm ($n = 29$)	Aortic dissection ($n = 13$)	χ^2	p value
Abdominal aorta	9 (31.0)	1 (7.7)	2.696	0.134
Thoracoabdominal aorta	4 (13.8)	3 (23.1)	0.557	0.657
DA	4 (13.8; 1 arising from PDA)	1 (7.7)	0.319	1.000
AA	2 (6.9)	3 (23.1)	2.241	0.162
Arch	2 (6.9)	–	0.941	1.000
Sinus of Valsalva	1 (3.4)	–	0.459	1.000
Root, AA	1 (3.4)	1 (7.7)	0.356	0.528
AA, annulus	1 (3.4)	–	0.459	1.000
AA, arch, DA	1 (3.4)	2 (15.4)	1.928	0.222
AA abdominal aorta	1 (3.4)	2 (15.4)	1.928	0.222
Arch, DA, abdominal aorta	1 (3.4)	–	0.459	1.000
DA, abdominal aorta	1 (3.4)	–	0.459	1.000
Root, AA, arch	1 (3.4)	–	0.459	1.000

AA ascending aorta, *DA* descending aorta, *PDA* patent ductus arteriosus

test. $p < 0.05$ was considered statistically significant.

Results

A total of 35 articles describing a single case or case series involving 40 patients were collected [2, 6–39]. There were 11 males and 29 females, with a male-to-female ratio of 1:2.6. The patients were at the age of 44.6 ± 16.8 (range 9–76; median 45) years ($n = 40$). No age difference was found between male and female patients (47.7 ± 22.0 years *vs.* 43.4 ± 14.7 years; $p = 0.473$). The SLE history was reported in 23 patients: in 3 patients, it was described as "new onset" [8, 10] and "long-standing" [9]. In the remaining 20 patients, the SLE history was 14.6 ± 11.5 (range 0–38; median 14) years ($n = 21$). It showed a longer SLE history in female patients than in male patients, which lacked significance (17.1 ± 11.9 years *vs.* 6.6 ± 4.7 years; $p = 0.073$). The duration of steroid use was 13.3 ± 9.4 (range 0–32; median 14) years ($n = 19$). In female patients, the duration of steroid use was longer than in the male patients, without significant difference (15.5 ± 9.6 years *vs.* 8.5 ± 7.6 years; $p = 0.134$). No difference was found between the SLE history and the duration of steroid use ($p = 0.555$). As many as 26 (65%) patients had a total of 51 associated disorders, of which hypertension and chronic renal failure were the most common (**Table 1**).

Aortic aneurysm occurred in 27 (67.5%) patients [6, 9, 11–15, 17, 19, 20, 23–27, 29, 31–36, 38], aortic dissection in 11 (27.5%) patients [2, 7, 8, 10, 16, 18, 25, 28, 30, 37, 39], concurrent aortic aneurysm and dissection in 2 (5%) patients [21, 22]. A comparison of patient information of the former two groups was shown in **Table 2**.

Aortic aneurysm often affected SLE patients in the abdominal aorta, whereas aortic dissection did not show any location predilection (**Table 3**). The type of aortic dissection was described in 12 patients: type A, 7 cases [2, 6, 7, 15, 21, 29, 36] and type B, 5 cases [20, 25, 27, 33, 38]. One patient with type A aortic dissection had a history of type B aortic dissection [15]. In aortic aneurysm patients, 2 (7.4%) were with pseudoa-

neurysms [13, 31], and aneurysmal rupture occurred in 4 (14.8%) patients [6, 13, 14, 20] (one pseudoaneurysm ruptured [13]). In contrast, in the aortic dissection group, abdominal rupture occurred in 1 (7.7%) patient with descending aortic dissection [35]. A mural thrombus was seen in 6 (22.2%) patients of the aortic aneurysm group [11, 13, 29, 31, 33, 35], while intramural hematoma was observed in 2 (15.4%) patients with aortic dissection [10, 37]. Aortic wall atherosclerosis and/or calcification occurred in 8 (8/27, 29.6%) aortic aneurysm patients [6, 9, 11, 29, 31, 34, 36, 38] and in 1 (1/9, 9.1%) aortic dissection patient [2]. In all, there was an occurrence of aortic atherosclerosis in 3 (3/9, 33.3%) patients [31, 34, 38], aortic wall calcification in 2 (2/9, 22.2%) patients [6, 11], and concurrent atherosclerosis and calcification in 4 (4/9, 44.4%) patients [2, 9, 29, 36]. The dimensions of 39 measurements of 36 aneurysms from 26 patients were shown, with a mean of 57.8 ± 22.4 (range 33–110; median 47) mm ($n = 33$; **Table 4**). The descending aorta showed the largest dimension, followed by the abdominal aorta, which extended >60 mm in average.

One patient suddenly died and lost the chance of treatment [34], and the treatment was not described for another patient [28]. Of the remaining 38 patients, 24 (63.2%) were surgically treated, 7 (18.4%) were interventionally treated, 2 (5.3%) were treated by hybrid procedures, and 5 (13.2%) were conservatively treated. A total of 27 (69.2%) experienced event-free survival, 4 (10.3%) were complicated (2 of them eventually died), and 9 (23.1%) died (**Tables 5 and 6**).

In the surgical group, 3 (12%) patients were operated on an urgent basis [13, 30, 37], 6 (24%) patients died, the death causes of 4 patients were given as late aortic dissection/rupture in 2 (50%) patients [31, 35], renal failure in 1 patient [37], and neurological sequelae in 1 patient [13]. In the interventional group, 2 (28.6%) patients underwent urgent interventions [18, 20]. As many as 4 patients had a complication: aortoesophageal fistula in 1 patient [14], and endoleaks in 3 patients with a respective type I, II, and III endoleaks in these patients [18, 21, 29].

Event-free survival of the surgical, interventional, and conservative groups did not differ significantly (75% *vs.* 42.9% *vs.* 80%; $\chi^2 = 4.258$; $p = 0.119$), and the mortality rates of the three groups were 25%, 12.5%, and 20%, respectively (**Table 6**).

Patients were at a follow-up of 19.6 ± 23.0 (range 1–78; median 9) months ($n = 23$). Postoperative use of immunosuppressive agents was described for 6 patients [7, 18, 20, 22, 25, 26], and

Z Rheumatol 2019 · 78:287–294 https://doi.org/10.1007/s00393-018-0555-x

S.-M. Yuan

Aortic aneurysm and dissection in systemic lupus erythematosus

Abstract

Aortic aneurysm and dissection are rare complications of systemic lupus erythematosus (SLE). The incidence, etiology, risk factors, and outcomes of this entity were largely unknown.

The study materials were based on the publications of aortic aneurysm or dissection due to SLE published between 2000 and 2017. A total of 36 articles reporting a single case or case series involving 40 patients were collected. The patients showed an absolute female dominance at a mean aneurysm age of 44.6 years. Steroid use was 13.3 ± 9.4 years prior to admission for management of aortic aneurysm or dissection. Aortic aneurysm occurred more commonly in abdominal than other segments of the aorta, whereas aortic dissection did not show any location predilection. Patients with open aortic operations showed a higher mortality rate than other groups; however, no statistical significance was reached. Interventional therapy was minimally invasive, but postinterventional endoleaks were a concerning problem.

SLE patients had significant risks for developing aortic aneurysm and dissection. Hypertension, long-term steroid use, and aortic pathological changes related to SLE seemed to be predominant risk factors for the occurrence of aortic aneurysm and dissection. Upon diagnosis, a surgical, interventional, or hybrid treatment should be performed to prevent severe sequelae and sudden deaths.

Keywords

Aneurysm, dissecting · Lupus erythematosus, systemic · Steroids

Aortenaneurysma und -dissektion bei systemischem Lupus erythematosus

Zusammenfassung

Das Aortenaneurysma und die Aortendissektion sind seltene Komplikationen des systemischen Lupus erythematosus (SLE). Inzidenz, Ätiologie, Risikofaktoren und Ergebnisse von dieser Entität waren bisher weitgehend unbekannt.

Diese Studie basiert auf Publikationen zu Aortenaneurysma und -dissektion in Verbindung mit SLE aus den Jahren 2000–2017.

Insgesamt wurden 36 Artikel mit 40 Patienten als Beschreibung eines Einzelfalls oder einer Fallserie in die Auswertung einbezogen.

Bei den Patienten herrschte das weibliche Geschlecht vor, das Durchschnittsalter bei Auftreten des Aneurysmas lag bei 44,6 Jahren. Die Dauer einer Steroidbehandlung betrug 13,3 ± 9,4 Jahre bis zur stationären Aufnahme wegen eines Aortenaneurysmas oder einer Aortendissektion. Ein Aortenaneurysma trat häufiger im abdominalen als in anderen Segmenten der Aorta auf, während für eine Aortendissektion keine Prädilektionsstellen festgestellt wurden. Patienten mit offener Aortenoperation wiesen eine höhere Mortalitätsrate auf als andere Gruppen; es wurde jedoch keine statistische Signifikanz erreicht. Interventionell therapiert wurde minimalinvasiv, ein Problem stellten allerdings postinterventionelle Endoleckagen dar.

Bei SLE-Patienten bestanden signifikante Risiken für die Entwicklung eines Aortenaneurysmas und einer Aortendissektion. Hypertonie, Langzeitsteroidtherapie und pathologische Veränderungen der Aorta durch den SLE schienen vorherrschende Risikofaktoren für das Auftreten von Aortenaneurysma und -dissektion zu sein.

Bei Diagnosestellung sollte eine chirurgische, interventionelle oder Hybridtherapie erfolgen, um schwere Folgen und plötzlichen Tod zu verhindern.

Schlüsselwörter

Aneurysma, dissezierend · Lupus erythematosus, systemisch · Steroide

Table 4 Dimensions of 39 measurements of 36 aneurysms from 26 patients (20 aortic aneurysm patients, 5 aortic dissection patients, and 1 aortic dissection with chronic dilation patient)

Location of aortic aneurysm	Mean ± SD	Range	Median	*n*
Ascending	60.0 ± 20.7	46.6–104	51	8
Abdominal	66.4 ± 27.3	40–110	55	9
Annulus	33	–	–	1
Arch	50.4 ± 16.7	40–80	45	5
Descending	68.3 ± 19.7	45–100	65	6
Descending-abdominal	42.5 ± 3.5	40–45	42.5	2
Root	44.6 ± 4.4	40–48.7	45	3
Thoracoabdominal	55.0 ± 19.1	40–80	50	4
Sinus of Valsalva	35	–	–	1

Table 5 Treatment of choice of aortic aneurysm and aortic dissection

Treatment	Aortic aneurysm ($n = 26$)	Aortic dissection ($n = 10$)	Aortic aneurysm and dissection ($n = 2$)	χ^2 (aortic aneurysm *vs.* aortic dissection)	*p* value (aortic aneurysm *vs.* aortic dissection)
Surgical	**16**	**7**	**1**	**0.224**	**0.716**
Abdominal aorta replacement	3	–	–	–	–
AA replacement	2	1	–	–	–
Surgical aortic repair	1	1	–	–	–
AA & arch replacements	–	2	–	–	–
AA replacement + innominate artery reimplantation	–	1	–	–	–
Abdominal aorta repair	2	–	–	–	–
Aortic bi-iliac graft implant	1	–	–	–	–
Aortic valve & AA replacements	1	–	–	–	–
Aortic valve re-suspension + AA & hemiarch replacements	–	1	–	–	–
Arch replacement + aberrant right subclavian artery reimplantation	–	–	1	–	–
Bentall operation	1	–	–	–	–
Bentall operation + hemiarch replacement + coronary artery bypass grafting	–	1	–	–	–
DA replacement	1	–	–	–	–
Patch repair of the aorta	1	–	–	–	–
Root replacement	1	–	–	–	–
Thoracoabdominal & infrarenal abdominal aorta replacements	1	–	–	–	–
Two-stage operations (for DA and infrarenal abdominal aorta)	1	–	–	–	–
Interventional (stent graft)	**4**	**2**	**1**	**0.111**	**1.000**
Hybrid	**2**	**0**	**0**	**0.814**	**1.000**
Right common iliac artery-left renal artery bypass & endovascular stent graft	1	–	–	–	–
AA & arch replacement + V-shaped descending aortoplasty & endovascular stent graft	1	–	–	–	–
Conservative	**4**	**1**	**0**	**0.175**	**1.000**

AA ascending aorta, *CPB* cardiopulmonary bypass, *DA* descending aorta

in 2 of them, a tapering dose was applied during the therapeutic course [7, 25].

No significances were found in the recovery and mortality rates between surgical and interventional treatments (recovery: 73.9% [17/23] *vs.* 57.1% [4/7]; $\chi^2 = 0.719$; $p = 0.640$; mortality: 26.1% [7/23] *vs.* 0% [0/7]; $\chi^2 = 2.779$; $p = 0.154$), or between aortic aneurysm and aortic dissection patients (recovery: 75% [12/16] *vs.* 57.1% [4/7]; $\chi^2 = 0.138$; $p = 1.000$; mortality: 18.8% [3/16] *vs.* 42.9% [3/7]; $\chi^2 = 0.806$; $p = 0.633$; **Table 6**). Pathological studies of the surgical specimens of the aorta and/or aortic valve were reported in 11 patients (**Table 7**).

A comparison of risk factors between aortic aneurysm and aortic dissection revealed that only cumulative steroid dose was much higher in aortic dissection patients than in the aortic aneurysm group (**Table 8**).

Discussion

The etiology of aortic aneurysm and dissection in SLE patients can be multifactorial. It was considered a result of pathological changes in the aorta of SLE patients, such as atherosclerosis, vasculitis, and cystic medial necrosis [40]. Esdaile et al. [41] reported that SLE itself represented an independent factor for premature atherosclerosis development, as patients with longer duration of SLE suffered more cardiovascular events. Clinical observations proved that prolonged steroid therapy in SLE patients predisposed to aortic aneurysm formation due to adverse effects in accelerating atherosclerosis, hypertension, and mucoid degeneration, and even cystic medial necrosis of the aortic wall by inhibition of formation of granulation tissue and chondroitin sulfate [42]. In short, the possible pathogenesis of aortic pathology was attributed to atherosclerosis, aortic elastic tissue degeneration, and vasculitis [4]. Men with SLE had a significantly higher incidence of aortic aneurysm, whereas women with SLE carried a significantly higher risk of aortic dissection [4]. Aoyagi et al. [7] described that the chronic inflammatory effect of SLE, a long-term history of smoking, the

Table 6 Patients' outcomes of 38 patients (27 aortic aneurysm/9 aortic dissection/2 aortic aneurysm and dissection patients), *n* (%)

Treatment (aortic aneurysm/ aortic dissection/aortic aneurysm and dissection)	Surgical (16/7/1)	Interventional (4/2/1)	Hybrid (2/0/0)	Conservative (4/1/0)	Untreated (1/0/0)
Recovered	12 (75)/4 (57.1)/1 (100)	2 (50)/2 (100)/0 (0)	2 (100)/0 (0)/0 (0)	–	–
Improved	–	–	–	3 (75)/0 (0)/0 (0)	–
No change	–	–	–	1 (25)/0 (0)/0 (0)	–
Complicated	1 (6.3)/0 (0)/0 (0)	2 (50)/0 (0)/1 (100)	–	–	–
Died	3 (18.8)/3 (42.9)/0 (0)	–	–	0 (0)/1 (100)/0 (0)	1 (100)/0 (0)/0 (0)

Table 7 Pathological studies of the surgical specimens of the aorta from 22 patients and of the aortic valve from 3 patients, *n* (%)

Specimen	Cystic medial necrosis	Focal medial destructions with necrosis	Mucinous/ hyaline degeneration	Medial hypertrophy	Slightly fibrotic	Focal hemorrhage	Endarteritis	Lymphoplasmacytic Infiltration	Unremarkable
Aortic media	5 (19.2) [12, 26, 32, 34, 37]	9 (34.6) [15, 31, 36]	1 (3.8) [38]	7 (26.9) [31, 38]	–	–	–	3 (11.5) [30, 36, 38]	1 (3.8) [7]
Aortic adventitia	–	–	–	–	–	1 (12.5) [2]	1 (12.5) [10]	4 (50) [12, 30, 36]	2 (25) [25, 29]
Aortic valve	–	–	1 (33.3) [19]	–	1 (33.3) [24]	–	–	–	1 (33.3) [26]

presence of systemic hypertension, and atherosclerosis contributed to the development of aortic dissection. However, Roman et al. [43] found that long-term treatment with corticosteroids reduced the risk of atherosclerosis.

Wei et al. [39] reported a mean age of 39.3 years of 21 SLE patients with aortic dissection and Kurata et al. [40] reported that the mean age of 35 SLE patients with aortic aneurysm was 44.5 years. Given that the female:male ratio in SLE is 10:1, a 2.6:1 ratio in aortic events still pointed to a higher risk in male SLE patients.

The pathologic study of aorta specimens of SLE patients showed Marfan-like changes, including cystic medial necrosis and elastic fiber disruption with deposition of mucopolysaccharides [42]. Guard et al. [44] found the pathological changes resembling those of Takayasu arteritis, including lymphoplasmacytic infiltrations and obliterative endarteritis of *vasa vasorum* in the aorta of SLE patients with aortic dissection. On excised aortic valve, although there were no findings of atherosclerosis, infection, cystic medial necrosis, or aortitis, mucinous and hyaline degeneration was observed, which seemed compatible with the findings previously reported in an SLE patient [19]. In one case, hyaline degeneration was present, with a diminution in both the smooth muscle cells and elastic fiber layers on the aneurysmal wall [45]. It was observed that atherosclerosis mostly affected the abdominal aorta. Subsequently, different pathological changes of aortic aneurysm were found according to different locations: a medial degeneration in the thoracic aorta and atherosclerosis in the abdominal aorta. Furthermore, mucoid degeneration might be a remarkable change of the aortic wall and/or aortic valve in SLE patients. Aortic valve insufficiency might be due to mucoid degeneration in addition to associated aortic cusp fenestration caused by infective endocarditis [46]. Cervera et al. [46] reported that valvular abnormalities were found in 44% of patients with SLE, and the incidence of valvular lesions increased with an increasingly detectable rate of the valve disorders by echocardiography. Aortic aneurysmal formation is actually an immune-related process, where the inflammatory cells, such as T and B cells, macrophages, mast cells, dendritic cells, and neutrophils, accumulate in the adventitia of the aortic wall, thereby triggering the inflammatory response [12].

Aoyagi et al. [7] analyzed 15 cases of aortic dissection in SLE patients including 14 cases from the literature and 1 case of their own. They concluded that the clinical features of the patient setting were onset at a young age, association with systemic disorders, prolonged steroid use, and presence of hypertension. The gender disparity of the incidence of aortic disorders secondary to SLE has been noted. The incidence of an aortic aneurysm was significantly higher in men with SLE than those without SLE, but the incidence of aortic dissection was significantly higher in women with SLE than those without SLE [4]. It has been proposed that female patients would have less potentiality to develop aortic aneurysm and dissection, as estrogens have antioxidant, antiplatelet, and vasodilating properties, thereby preventing the aorta from atherosclerosis [40]. In most SLE patients, aortic aneurysms often develop in their third–fifth decade of age, much earlier than the normal population. Moreover, a group of SLE patients for abdominal aortic aneurysm repair showed much younger ages than non-SLE control patients for the same operation [31].

Kurata et al. [40] summarized the patient information of 26 articles re-

Table 8 A comparison of risk factors between aortic aneurysm and aortic dissection

Risk factor	Aortic aneurysm ($n = 23$)	Aortic dissection ($n = 8$)	χ^2 (t)	p value
Skin rash (n)	2	1	0.098	1.000
(Rheumatic) fever (n)	2	1	0.098	1.000
Smoking (n)	2	0	0.744	1.000
Hypertension (n)	8	6	3.876	0.097
Hypertension duration (years)	25 ($n = 1$)	0.58 ($n = 1$), 5 ($n = 1$)	–	–
Hypertension medication	Captopril 25 mg/d ($n = 1$), nifedipine & propranolol ($n = 1$), amlodipine 5 mg, twice daily, clonidine 0.1 mg, thrice daily, hydrochlorothiazide 25 mg daily, losartan 100 mg daily, metolazone 7.5 mg twice daily and etacrynic acid 25 mg twice daily ($n = 1$)	Amlodipine 10 mg/day, doxazosin 4 mg/day, minoxidil 5 mg/day and propranolol 40 mg/day ($n = 1$)	–	–
Blood pressure, mm Hg	–	171/151 ($n = 1$), 180/120 ($n = 1$), 260/130 ($n = 1$)	–	–
Dyslipidemia	2	0	0.744	1.000
Renal failure/hemodialysis	5	1	0.325	1.000
Steroid cumulative dose, g	27.6 ± 14.9 (range, 9.1–64.2; median, 23.1) ($n = 12$)	78.3 ± 51.1 (range, 12.6–136.8) ($n = 4$)	–3.243	0.006
Pancytopenia	1	0	0.359	1.000
Proteinuria	6	1	0.627	0.642
White blood cell count, $<4.0 \times 10^9$/L/$>4.0 \times 10^9$/L	1/0	–	–	–
Erythrocyte sedimentation rate, (+)/(–)	2/1	2/1	0.000	1.000
C-reactive protein, (+)/(–)	5/0	2/4	5.238	0.061
C3, C4, reduced/normal	3/1	2/2	0.533	1.000
Ch50, reduced/normal	–	0/1	–	–
Anti-double-strand deoxyribonucleic acid (DNA), (+)/(–)	9/0	2/1	3.273	0.250
Antinuclear antibody, (+)/(–)	10/0	2/1	3.611	0.231
Lupus erythematous cell reactions, (+)/(–)	1/0	–	–	–
Extractable nuclear antigen (ENA) antibodies, (+)/(–)	1/0	–	–	–
Anti-Smith, anti-ribonucleoprotein (RNP), anti-Ro, (+)/(–)	1/0	–	–	–
Anticardiolipin, (+)/(–)	1/0	1/0	–	–
Protoplasmic-staining antineutrophil cytoplasmic antibodies, (+)/(–)	1/0	–	–	–
Nuclear factor GMb, (+)/(–)	–	1/0	–	–
Myeloperoxidase antineutrophil cytoplasm antibody, (+)/(–)	–	1/0	–	–
Proteinase 3 antineutrophil cytoplasm antibody, (+)/(–)	–	1/0	–	–
Vasculitis, (+)/(–)	2/3	3/3	0.110	1.000
Activity				
– Active	8	4	0.579	0.676
– Active in remission	8	0	3.750	0.076
– Inactive	7	4	0.992	0.405

bid >twice daily, *tid* >thrice daily

Table 9 A comparison of the statistical results of aortic aneurysm/dissection in SLE patients between Kurata's and the present study

Variable	Kurata et al.	Present	χ^2	*P*-value
Aneurysm age (years)	44.5 ± 15.2	44.6 ± 16.6	–	–
Steroid duration (years)	12.6 ± 9.73	14.6 ± 8.9	–	–
Surgical treatment (%)	21/29 (60.0)	25/39 (64.1)	0.10	0.848
Surgical mortality	11/29 (31.4)	6/24 (25)	0.52	0.578
Atherosclerosis	16/23 (69.6)	7/40 (17.5)	14.00	0.001
Dissection	18/34 (52.9)	12/40 (30)	4.013	0.059
Aneurysmal rupture	8/34 (23.5)	5/31 (16.1)	0.37	0.762
Hypertension	19/25 (76.0)	13/40 (32.5)	4.03	0.053
Cystic medial necrosis	13/21 (61.9)	3/11 (27.3)	1.26	0.328
Vasculitis	8/23 (34.8)	6/22 (45.5)	0.16	0.766
20-year survival	14/22 (63.6)	–	–	–

ported between 1969 and 2008, and found that the mean aneurysm age was 44.5 ± 15.2 years and the mean steroid duration was 12.6 ± 9.73 years, which were compatible to the results of the present study (**Table 9**). However, the incidences of hypertension and atherosclerosis shown in this study were much lower than in the previous report.

Although an unruptured aortic aneurysm usually does not cause symptoms, it may incur severe complications if left untreated, *e.g.*, right ventricular outflow tract obstruction, coronary artery occlusion, aortic valve regurgitation, complete heart block, or refractory ventricular arrhythmias [4]. The correlative studies by Kurate et al. [40] revealed that the SLE age was positively related to the aneurysm age and inversely related to long-term survival. These conclusions facilitated the treatment of choice in such patients.

Endovascular thoracic aortic aneurysm repair has emerged as an alternative to conventional open surgery considering its advantages over open surgery in terms of lower surgical morbidity and mortality. Nevertheless, its clinical use is limited due to the concern of spinal ischemia, which often requires visceral and intercostal arterial reconstructions [6]. A recently developed hybrid procedure consisting of retrograde visceral revascularization and endoluminal exclusion has facilitated the treatment of thoracoabdominal aortic aneurysms in high-risk patients eligible for open surgery [6]. It was once recommended to administer a low-dose steroid to prevent aortic aneurysm formation and occurrence of aortic dissection [47], but the outcomes warrant long-term observations. The associated immunosuppressive diseases including antiphospholipid antibody syndrome in SLE patient may exaggerate SLE severity by predisposing to thrombosis and atherosclerosis. Concurrent therapy of the associated immunosuppressive disease is an important measure to control SLE and complications [34].

The incomplete data from the literature has led to some statistical bias in this study. The incidence of atherosclerosis was underestimated rather than a true one. Prospective studies based on large patient populations for accurate evaluations of the aortic complications in SLE patients are warranted.

SLE patients have significant risks of developing aortic aneurysm and dissection. Hypertension, prolonged steroid use, and aortic pathological changes related to SLE can be predominant risk factors of the occurrence of aortic aneurysm and dissection in such patients. The intergroup difference in cumulative steroid doses hint that higher cumulative steroid doses predicting aortic dissection. Aortic aneurysm and dissection occur more commonly in the abdominal aorta than in the other segments of aorta. Patients with open aortic operations tend to show a higher mortality rate than the other groups. Interventional therapy is minimally invasive, but postinterventional endoleaks are a concerning problem, which anticipates plausible resolutions.

Corresponding address

Shi-Min Yuan, MD, PhD
Department of Cardiothoracic Surgery, The First Hospital of Putian, Teaching Hospital, Fujian Medical University
389 Longdejing Street, Chengxiang District, 351100 Putian, Fujian Province, China
shiminyuan@126.com

Compliance with ethical guidelines

Conflict of interest. S.-M. Yuan declares that he has no competing interests.

This article does not contain any studies with human participants or animals performed by any of the authors.

References

1. Khan AS, Spiera H (1998) Association of aortic aneurysm in patients with systemic lupus erythematosus: a series of case reports and a review of the literature. J Rheumatol 25(10):2019–2021
2. Apostolova M, Shoib M, Hussain A (2011) A rare case of acute type A aortic dissection in a patient with systemic lupus erythematosus. Rheumatol Rep 3:e6
3. Guy A, Tiosano S, Comaneshter D, Tekes-Manova D, Shovman O, Cohen AD, Amital H (2016) Aortic aneurysm association with SLE—a case-control study. Lupus 25(9):959–963
4. Wang SH, Chang YS, Liu CJ, Lai CC, Chen TJ, Chen WS (2014) Incidence and risk analysis of aortic aneurysm and aortic dissection among patients with systemic lupus erythematosus: a nationwide population-based study in Taiwan. Lupus 23(7):665–671
5. Choudhary SK, Bhan A, Sharma R, Airan B, Kumar AS, Venugopal P (1997) Sinus of Valsalva aneurysms: 20 years' experience. J Card Surg 12(5):300–308
6. Akagi H, Sakaguchi S, Irie H, Nakao Y, Nishimine K, Sakai K (2013) Successful hybrid treatment for a ruptured thoracoabdominal aortic aneurysm in a patient with systemic lupus erythematosus. Ann Vasc Dis 6(2):202–205
7. Aoyagi S, Akashi H, Otsuka H, Sakashita H, Okazaki T, Tayama AK (2002) Acute type A aortic dissection in a patient with systemic lupus erythematosus. Jpn Heart J 43(5):567–571
8. Arul Rajamurugan PS, Panchapakesa Rajendran C, Rukmangatharajan S, Kanakarani P, Rajeswari S, Ravichandran R (2007) Aortic dissection in a case of systemic lupus erythematosus. Lupus 16(12):1001–1003
9. Augoustides JG, Pochettino A, Carpenter J (2008) Surgical management of thoracoabdominal

aortic aneurysm associated with systemic lupus erythematosus. J Thorac Cardiovasc Surg 136(1):215–216
10. Brinster DR, Grizzard JD, Dash A (2009) Lupus aortitis leading to aneurysmal dilatation in the aortic root and ascending aorta. Heart Surg Forum 12(2):E105–E108
11. Chang WL, Huang CM, Yang YH, Lin YT, Chiang BL (2004) Aortic aneurysm in systemic lupus erythematosus. J Microbiol Immunol Infect 37(5):310–312
12. Corominas H, Tsokos M, Quezado M, Tsokos GC (2017) Aneurysm of the ascending aorta in systemic lupus erythematosus: case report and review of the literature. Eur J Rheumatol 4(2):133–135
13. Correia AS, Gonçalves A, Vaz SM, Amorim MJ, Maciel MJ (2012) Unusual type A aortic dissection. Rev Port Cardiol 31(2):175–176
14. de Conti DO, Dias RR, Fiorelli AI, Stolf NA (2011) Ruptured thoracic aortic aneurysm in patient with systemic lupus erythematosus. Rev Bras Cir Cardiovasc 26(1):128–130
15. Dessertenne G, Canaud L, Marty-Ané C, Alric P (2015) Saccular thoracoabdominal aneurysms in systemic lupus erythematosus. Ann Vasc Surg 29(7):1448.e1–1448.e3
16. Dobrilovic N, Arslan B, McCarthy WJ, March RJ, Turba UC, Michalak L, Delibasic M, Raman J (2016) Delayed retrograde ascending aortic dissection after endovascular repair of descending dissection. Ann Thorac Surg 101(6):2357–2358
17. Foffa I, Festa PL, Ait-Ali L, Mazzone A, Bevilacqua S, Andreassi MG (2009) Ascending aortic aneurysm in a patient with bicuspid aortic valve, positive history of systemic autoimmune diseases and common genetic factors: a case report. Cardiovasc Ultrasound 7:34
18. Gulsen F, Cantasdemir M, Ozluk E, Arisoy N, Numan F (2011) Endovascular stent-graft placement for ruptured dissecting aortic aneurysm in an adolescent patient with systemic lupus erythematosus: case report. Emerg Radiol 18(6):499–502
19. Hirose T, Kameda Y, Yoshikawa Y, Abe T, Hayata Y, Taniguchi S (2012) Aortic root replacement for Valsalva sinus aneurysm with lupus erythematosus. Asian Cardiovasc Thorac Ann 20(2):193–195
20. Hua SR, Liu CW, Zheng YH, Wu WW (2014) Dysphagia as the mere chief complaint of ruptured thoracic aneurysm in a patient with systemic lupus erythematosus. Ann Vasc Surg 28(7):1792.e1–1792.e3
21. Kaladji A, Dumenil A, Castro M, Haigron P, Heautot JF, Haulon S (2013) Endovascular aortic repair of a postdissecting thoracoabdominal aneurysm using intraoperative fusion imaging. J Vasc Surg 57(4):1109–1112
22. Kitamura H, Kimura A, Fukaya S, Okawa Y, Komeda M (2016) Emergent total arch replacement for acute type A aortic dissection with aberrant right subclavian artery in a systemic lupus erythematosus patient. Gen Thorac Cardiovasc Surg 64(1):25–27
23. Klimkowski WJ, Roychoudhury P, Markova T (2005) Abdominal aortic aneurysm in a patient with systemic lupus erythematosus. Hosp Physician 41(12):29–32
24. Kolesar A, Bily B, Spak L, Luczy J, Artemiou P, Sabol F (2015) "V" aortoplasty of the proximal descending aorta in the elephant trunk procedure. J Cardiothorac Surg 10:13
25. Kunihara T, Sasaki S, Nishibe T, Akimaro Kudo F, Shiiya N, Murashita T, Yasuda K (2002) Successful endovascular stent-grafting for thoracic aortic aneurysms in systemic lupus erithematosus. Report of 2 cases and review of the literature. J Cardiovasc Surg (Torino) 43(2):235–240
26. Miyashita T, Abe Y, Kato Y, Nakagawa E, Komatsu R, Hattori K, Shibata T, Yoshioka K, Naruko T, Itoh A (2010) Aortic aneurysm with severe aortic regurgitation in a patient with systemic lupus erythematosus. Intern Med 49(20):2263–2266
27. Murana G, Cefarelli M, Kloppenburg G, Morshuis WJ, Heijmen RH (2016) Surgical exclusion of a saccular aneurysm within a patent ductus arteriosus in an adult patient with Ortner's syndrome. Future Cardiol 12(6):613–616
28. Nagao T, Ito K, Tsuboi H, Ide Y (2012) Rare complications of systemic lupus erythematosus. Intern Med 51(21):3101–3102
29. Ng NZP, Chong TT (2017) Endovascular aneurysm repair (EVAR) of an infrarenal abdominal aortic aneurysm (AAA) in a young patient with systemic lupus erythematosus (SLE). EJVES Short Rep 37:8–11
30. Oberwalder PJ, Tilz G, Rigler B (2003) Spontaneous acute type A aortic dissection as a result of autoimmune aortitis without previous aortic dilatation in a 43-year-old man. J Thorac Cardiovasc Surg 125(2):413
31. Ohara N, Miyata T, Kurata A, Oshiro H, Sato O, Shigematsu H (2000) Ten years' experience of aortic aneurysm associated with systemic lupus erythematosus. Eur J Vasc Endovasc Surg 19(3):288–293
32. Rached-d'Astous S, Dahdah N, Brochu P, Saint-Cyr C (2014) Rapidly progressive aortic aneurysmal dilation in a child with systemic lupus erythematosus: too early too severe. BMJ Case Rep. https://doi.org/10.1136/bcr-2013-201014
33. Rapondjieva A, Dobreva N, Delijska B (2001) A case of nondissecting abdominal aortic aneurysm associated with systemic lupus erythematosus. Nephrol Dial Transplant 16(5):1079–1080
34. Sato J, Kawakami T, Nakabayashi K, Fukuoka K, Hirano K, Terado Y, Yokoyama K, Ohtsuka T, Ohkura Y, Fujioka Y, Kurata A (2008) Multiple aortic aneurysms complicated by a rupture in the systemic lupus erythematosus: a case report. Pathol Res Pract 204(11):845–850
35. Silvestri V, Simonte G (2017) Aortic pathology in systemic Lupus Erythematosus: a case report and review of literature. Ann Vasc Surg 43:312.e5–312.e12
36. Takagi H, Mori Y, Iwata H, Kimura M, Itokazu M, Shimokawa K, Hirose H (2002) Nondissecting aneurysm of the thoracic aorta with arteritis in systemic lupus erythematosus. J Vasc Surg 35(4):801–804
37. Tsuji T, Ishiguro Y, Nakui Y, Murata Y, Munakata A, Onozuka N, Fukui K, Suzuki S, Yamagishi S (2001) A case of dissecting aortic aneurysm with cystic medial necrosis in systemic lupus erythematosus. Mod Rheumatol 11(3):238–241
38. Washiyama N, Kazui T, Takinami M, Yamashita K, Terada H, Muhammad BA, Miura K (2000) Surgical treatment of recurrent abdominal aortic aneurysm in a patient with systemic lupus erythematosus. J Vasc Surg 32(1):209–212
39. Wei HY, Chung HT, Wu CT, Huang JL (2011) Aortic dissection complicated with hemothorax in an adolescent patient with systemic lupus erythematosus: case report and review of literature. Semin Arthritis Rheum 41(1):12–18
40. Kurata A, Kawakami T, Sato J, Sakamoto A, Muramatsu T, Nakabayashi K (2011) Aortic aneurysms in systemic lupus erythematosus: a meta-analysis of 35 cases in the literature and two different pathogeneses. Cardiovasc Pathol 20(1):e1–e7
41. Esdaile JM, Abrahamowicz M, Grodzicky T, Li Y, Panaritis C, du Berger R, Côte R, Grover SA, Fortin PR, Clarke AE, Senécal JL (2001) Traditional Framingham risk factors fail to fully account for accelerated atherosclerosis in systemic lupus erythematosus. Arthritis Rheum 44(10):2331–2337
42. Choi KH, Rim SJ, Lee SK, Jang BC, Cho SH (1999) Dissecting aortic aneurysm with aortic-valve insufficiency in systemic lupus erythematosus. Nephrol Dial Transplant 14(4):969–973
43. Roman MJ, Shanker BA, Davis A, Lockshin MD, Sammaritano L, Simantov R, Crow MK, Schwartz JE, Paget SA, Devereux RB, Salmon JE (2003) Prevalence and correlates of accelerated atherosclerosis in systemic lupus erythematosus. N Engl J Med 349(25):2399–2406
44. Guard RW, Gotis-Graham I, Edmonds JP, Thomas AC (1995) Aortitis with dissection complicating systemic lupus erythematosus. Pathology 27(3):224–228
45. Yamazaki K (2004) Systemic lupus erythematosus with hepatic aneurysm, Valsalva sinus aneurysm and associated polyangiitis: caneurysmal wall remodeling with dense fibrosis and calcification mediated by residual smooth muscle cells. Lupus 13:54–59
46. Cervera R, Font J, Paré C, Azqueta M, Pérez-Villa F, López-Soto A, Ingelmo M (1992) Cardiac disease in systemic lupus erythematosus: prospective study of 70 patients. Ann Rheum Dis 51(2):156–159
47. Khan AS, Spiera H (1998) Association of aortic aneurysm in patients with systemic lupus erythematosus: a series of case reports and a review of the literature. J Rheumatol 25(10):2019–2021