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Cardiac Involvement in Childhood-Onset Systemic Lupus Erythematosus: A Literature Review of Pathophysiology, Diagnosis, and Management

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ABSTRACT

Systemic lupus erythematosus (SLE) is an autoimmune disorder that arises from a loss of immune tolerance and damages many organs through autoantibodies, immune-complex deposition, and inflammation. Childhood-onset SLE (cSLE) accounts for about 15–20% of cases and follows a more aggressive course than adult-onset disease. The heart is a frequent target: pericarditis, pericardial effusion, myocarditis, Libman–Sacks endocarditis, and conduction abnormalities can involve every cardiac layer, and many of these lesions produce no symptoms. This narrative review summarizes immunopathology, clinical spectrum, detection, and management of cardiac involvement in SLE, with emphasis on children. Endothelial activation, neutrophil extracellular traps, excess type I interferon, dysfunctional T- and B-cell subsets, and antiphospholipid antibodies drive vascular injury, valve damage, and thrombosis. The 2012 Systemic Lupus International Collaborating Clinics (SLICC) and the 2019 European League Against Rheumatism/American College of Rheumatology (EULAR/ACR) criteria classify the disease, and the SLE Disease Activity Index 2000 (SLEDAI-2K) tracks its activity. Electrocardiography and echocardiography uncover subclinical involvement; in one pediatric cohort, 29.3% of children had electrocardiographic abnormalities, and European pediatric recommendations advise both tests at diagnosis. Management combines hydroxychloroquine for every patient, glucocorticoids reduced to the smallest dose that controls the disease, immunosuppressive agents for organ-threatening disease, anticoagulation for thrombosis, supportive cardiovascular and renal care, and tailored exercise. Routine cardiac screening of children with SLE allows earlier treatment of silent disease.

Keywords: childhood-onset systemic lupus erythematosus; cardiac involvement; pericardial effusion; Libman–Sacks endocarditis; echocardiography; hydroxychloroquine

INTRODUCTION

In systemic lupus erythematosus (SLE), the immune system loses tolerance to self-antigens, produces autoantibodies, and inflames tissues in many organs over a chronic, relapsing course [1]. Children and adolescents make up about 15–20% of patients with SLE. Childhood-onset SLE (cSLE) follows a more aggressive course than adult-onset disease, with higher disease activity, more long-term damage, and frequent renal involvement, and Asian patients tend to have more serious manifestations and poorer outcomes [2].

Cardiac involvement is a major source of morbidity and mortality in SLE, and the disease can injure the pericardium, myocardium, valves, conduction tissue, and coronary arteries [3]. Infection and cardiovascular disease rank among the most common causes of death in patients with SLE [4]. In children, cardiac lesions often remain silent. Guevara et al. examined 19 children with SLE and found abnormalities on electrocardiography (ECG) or echocardiography in six (32%), several of whom had no cardiac symptoms; a recent history of palpitations was the only factor associated with these abnormalities [5].

Pericardial disease carries a measurable risk. In a national inpatient database from the United States, pericardial effusion affected 0.1% of hospitalized children; 15% of these children had a rheumatological diagnosis, and 6.8% of all affected children died in hospital [6]. Among 689 adults with SLE in Taiwan, the 113 patients with lupus pericarditis had a mortality of 31.9% during follow-up, compared with 16.1% in those without pericarditis, and pericarditis independently predicted poorer survival (hazard ratio 1.96) [7]. Severe lupus myocarditis is rare in children but can be fatal [8].

Pediatric data on cardiac involvement in SLE remain limited, and data from Southeast Asia are scarcer still, although cSLE is more common there than in Western populations [2]. This review summarizes the immunopathology, clinical spectrum, diagnosis, and management of cardiac involvement in SLE, with attention to children.

METHODS

This article is a narrative literature review. The authors identified sources mainly through PubMed and ScienceDirect, used the NCBI Bookshelf for reference chapters, and located a book chapter and a regional journal article through Google Scholar and the reference lists of retrieved articles. The sources include classification and treatment recommendations, cohort, cross-sectional, and pathology studies, a meta-analysis, a case series, a case report, review articles, and reference chapters published between 1977 and 2024. The authors selected publications for their relevance to the immunopathology, clinical spectrum, diagnosis, and management of cardiac involvement in SLE, and synthesized the findings by theme. The review did not include a formal quality appraisal or a meta-analysis.

The Immune Response and Loss of Tolerance in SLE

A healthy immune response removes viruses, bacteria, and other foreign materials. Macrophages and dendritic cells recognize and engulf antigens. Activated B cells mature into plasma cells that secrete antibodies, which neutralize antigens or tag them for destruction by other immune cells. Helper T cells release cytokines that coordinate the response and stimulate B cells and cytotoxic T cells, and cytotoxic T cells kill infected host cells [9].

In SLE, genetic susceptibility and environmental triggers such as infection break this tolerance, and the immune system turns against self-antigens through both innate and adaptive pathways [1,10]. Toll-like receptors on immune cells sense DNA and RNA released from damaged cells and switch on inflammatory signaling and interferon production. Neutrophils add to the antigen load through NETosis, in which they extrude nuclear material that further stimulates autoimmunity. Dysfunctional T cells secrete abnormal cytokines and help autoreactive B cells produce autoantibodies against nuclear components. These autoantibodies form immune complexes that settle in tissues and cause inflammation and organ damage, and the mutual activation of T and B cells keeps the cycle going [10].

Mechanisms of Cardiac and Vascular Injury

Vascular injury in SLE starts with abnormal activation of the endothelium. Activated endothelial cells release signals that recruit monocytes, which bind to the vessel wall through adhesion molecules such as intercellular adhesion molecule-1 (ICAM-1), vascular cell adhesion molecule-1 (VCAM-1), and E-selectin; patients with SLE carry higher levels of these molecules. The lectin-like oxidized low-density lipoprotein receptor-1 (LOX-1) binds oxidized LDL and raises the secretion of tumor necrosis factor-alpha (TNF-α), interleukin (IL)-6, and IL-12, which draws in more monocytes. Patients with severe SLE show higher VCAM-1 levels and more apoptotic endothelial cells, which links these markers with disease activity and vascular damage. Recruited monocytes turn into foam cells and enlarge atherosclerotic plaques [4].

Innate immune cells amplify this damage. Neutrophils and their low-density granulocyte subset release neutrophil extracellular traps, which in excess injure the endothelium and promote clotting. Plasmacytoid dendritic cells, activated in error by self-nucleic acids, secrete excess type I interferon, which sustains inflammation, impairs vascular repair, and favors atherosclerosis and thrombosis. Natural killer cells fall in number as disease activity rises, and the remaining cells release inflammatory cytokines and cytotoxic granules that contribute to atherosclerosis [4].

Adaptive immunity shapes the cardiovascular course as well. Overactive $CD4^+$ T cells of the T helper 1 and T helper 17 subsets respond to type I interferon and contribute to vascular injury and thrombosis. Regulatory T cells, which restrain inflammation and protect the heart and vessels in health, are defective in SLE. B1 cells secrete immunoglobulin M antibodies that clear oxidized LDL and apoptotic cells, a protective effect that SLE weakens, whereas B2 cells promote atherosclerosis [4].

Autoantibodies link these pathways to specific cardiac lesions. Antiphospholipid antibodies occur in about one-third of patients with SLE, and 10–15% of patients develop the clinical features of secondary antiphospholipid syndrome, a thrombotic disorder [4]. Immune complexes formed by non-organ-specific autoantibodies deposit in cardiac tissue and underlie Libman–Sacks endocarditis, myocarditis, and pericarditis, while antiphospholipid antibodies favor coronary thrombosis, valve disease, and intramyocardial vasculopathy. Anti-Ro/SSA and anti-La/SSB antibodies target the conduction system, as seen in the heart block of neonatal lupus [3].

Spectrum of Cardiac Manifestations

- ***Pericarditis and Pericardial Effusion***

Pericardial involvement is common in SLE. Postmortem studies have reported pericarditis in about 62% of patients, and a clinical series found it in 38 of 97 patients [4]. Pericarditis inflames the pericardium and causes chest pain. The European Society of Cardiology (ESC) diagnoses acute pericarditis when at least two of four features are present: pericarditic chest pain, a pericardial rub, new widespread ST-segment elevation or PR depression, and a new or worsening pericardial effusion. The ESC also classifies pericarditis by its course. Incessant pericarditis persists for more than 4–6 weeks but less than 3 months without remission, recurrent pericarditis returns after a symptom-free interval of at least 4–6 weeks, and chronic pericarditis lasts longer than 3 months [11]. Pericardial effusion is an accumulation of excess fluid in the pericardial sac.

A slow accumulation of fluid may cause no symptoms, whereas a large or rapid effusion can compress the heart and lead to cardiac tamponade [11]. Serosal disease also carries weight in classification: the 2019 European League Against Rheumatism/American College of Rheumatology (EULAR/ACR) criteria assign 5 points to pleural or pericardial effusion and 6 points to acute pericarditis [12].

- ***Myocarditis***

Myocarditis is inflammation of the heart muscle. It weakens contraction and can cause dyspnea, chest pain, and palpitations. Lupus myocarditis is less common than pericarditis but represents a serious complication [4]. Kim et al. described three adolescents with severe lupus myocarditis whose presentations differed, and concluded that this rare complication can cause death, and that early recognition and treatment may improve outcomes [8].

- ***Valvular Disease and Libman–Sacks Endocarditis***

Valvulitis inflames the heart valves and can leave them thickened, regurgitant, or stenotic, which alters blood flow through the heart; these lesions often produce no symptoms [13]. The characteristic valve lesion of SLE is Libman–Sacks endocarditis, a form of non-bacterial thrombotic endocarditis in which sterile vegetations of immune complexes, mononuclear cells, fibrin, and platelet thrombi form on the valve leaflets. It affects the mitral valve most often, followed by the aortic valve, and occurs in 6–11% of patients with lupus. Embolism accounts for most of its clinical manifestations, and the involved valves may become regurgitant [14]. Light and immunofluorescence microscopy of these lesions supports an immune-complex mechanism [15].

Antiphospholipid antibodies raise this risk. A meta-analysis of 23 echocardiographic studies with 1,656 patients with SLE found that antibody-positive patients had about three times the odds of heart valve disease (odds ratio [OR] 3.13) and of Libman–Sacks endocarditis (OR 3.51), and lupus anticoagulant (OR 5.88) and IgG anticardiolipin (OR 5.63) carried the highest risk. The authors advised systematic echocardiography for antibody-positive patients [16]. Subclinical valve lesions are frequent. In a cohort of 59 patients with a mean age of 31 years, Mohamed et al. found mitral regurgitation in 33.9%, tricuspid regurgitation in 32.2%, mitral thickening in 18.6%, aortic thickening in 13.6%, pericardial effusion in 13.6%, and pulmonary hypertension in 8.5% [17].

Diagnosis of SLE

- ***Clinical and Laboratory Assessment***

Early SLE often presents with joint or muscle pain, skin rashes, and, in some patients, inflammation of internal organs [1]. The antinuclear antibody (ANA) test serves as the screening test, and a positive ANA at a titer of at least 1:80 forms the entry criterion of the 2019 EULAR/ACR classification. Other conditions can also produce a positive ANA, so clinicians confirm the diagnosis with more specific tests, such as anti-double-stranded DNA (anti-dsDNA) and anti-Smith antibodies, and with complement levels [1,12].

Clinicians also order a complete blood count, serum complement (C3 and C4), urinalysis, and the erythrocyte sedimentation rate (ESR) to look for blood, kidney, and inflammatory involvement. The Systemic Lupus International Collaborating Clinics (SLICC) classification counts a lymphocyte count below $1.0 \times 10^3/\mu L$ as a clinical criterion [18], and ESR values track renal and overall disease activity [19].

- ***Classification Criteria***

The 2012 SLICC criteria contain 11 clinical and 6 immunologic criteria. A patient is classified as having SLE with at least four criteria, including at least one clinical and one immunologic criterion, or with biopsy-proven lupus nephritis in the presence of ANA or anti-dsDNA antibodies [18]. The European pediatric recommendations of the Single Hub and Access point for paediatric Rheumatology in Europe (SHARE) initiative endorse the SLICC criteria for classifying cSLE [20].

The 2019 EULAR/ACR criteria require a positive ANA as an entry criterion and then score weighted items from seven clinical domains (constitutional, hematologic, neuropsychiatric, mucocutaneous, serosal, musculoskeletal, and renal) and three immunologic domains (antiphospholipid antibodies, complement proteins, and SLE-specific antibodies). Items carry 2 to 10 points, and a total of at least 10 points, including at least one clinical criterion, classifies a patient as having SLE. In a validation cohort of 1,270 patients, the new criteria reached a sensitivity of 96.1% and a specificity of 93.4%, compared with 96.7% and 83.7% for the SLICC criteria. Both systems serve to classify patients for research, so the diagnosis in an individual child remains a clinical judgment [12]. Table 1 compares the two systems.

TABLE 1: Comparison of the SLICC 2012 and EULAR/ACR 2019 Classification Criteria for Systemic Lupus Erythematosus.

Feature	SLICC 2012 [18]	EULAR/ACR 2019 [12]
Entry requirement	None	Positive ANA at a titer of at least 1:80 on HEp-2 cells, or an equivalent positive test, at least once
Structure	11 clinical and 6 immunologic criteria	7 clinical and 3 immunologic domains; items weighted from 2 to 10 points
Pericardial items	Serositis, including typical pericardial pain, pericardial effusion, pericardial rub, or pericarditis on ECG	Pleural or pericardial effusion (5 points); acute pericarditis (6 points)
Classification rule	At least 4 criteria with at least 1 clinical and 1 immunologic criterion, or biopsy-proven lupus nephritis with ANA or anti-dsDNA	At least 10 points with at least 1 clinical criterion; only the highest-weight item in each domain counts
Performance in the EULAR/ACR validation cohort (n = 1,270) [12]	Sensitivity 96.7%; Specificity 83.7%	Sensitivity 96.1%; specificity 93.4%
Pediatric use	Endorsed by SHARE for classifying cSLE [20]	Published after the SHARE recommendations

ANA, antinuclear antibody; anti-dsDNA, anti-double-stranded DNA antibody; cSLE, childhood-onset systemic lupus erythematosus; ECG, electrocardiography; EULAR/ACR, European League Against Rheumatism/ American College of Rheumatology; SHARE, Single Hub and Access point for paediatric Rheumatology in Europe; SLICC, Systemic Lupus International Collaborating Clinics.

- ***Disease Activity***

The Systemic Lupus Erythematosus Disease Activity Index (SLEDAI) scores 24 weighted clinical and laboratory descriptors that reflect active disease during the preceding 10 days, and a higher total indicates greater activity. The SLEDAI-2K revision counts persistent rash, mucosal ulcers, alopecia, and proteinuria, which the original version scored only when new or recurrent. In a cohort of 960 patients, SLEDAI-2K showed a correlation of 0.97 with the original index and predicted mortality as well as the original did [21]. Studies use different cut-offs to grade activity as mild, moderate, or severe, so comparisons between studies need care.

Detection of Cardiac Involvement

- ***Electrocardiography***

An electrocardiogram captures cardiac electrical signals through electrodes placed on the limbs and chest [22]. Among 41 children with SLE, AlTwajery et al. found ECG abnormalities in 12 (29.3%): ST–T changes and a prolonged QT interval in 9.8% each, right bundle branch block in 7.3%, and low QRS voltage in 2.4%. Abnormal tracings occurred more often in children with anti-Ro/SSA antibodies (8 of 16) than in those without them (4 of 25), and they were also associated with low platelet counts [23].

- ***Echocardiography***

Echocardiography uses high-frequency sound waves to image the cardiac chambers, valves, and great vessels [24]. It detects pericardial effusion, valvular thickening and regurgitation, and impaired ventricular function, including lesions that cause no symptoms [17]. Cardiopulmonary involvement in cSLE is uncommon but often asymptomatic at first, so the SHARE recommendations advise ECG and echocardiography for every child with SLE at diagnosis and intermittent monitoring afterwards [20]. Patients with antiphospholipid antibodies warrant systematic echocardiographic follow-up [16].

Management

Management of cardiac involvement in SLE aims to control inflammation, prevent complications, and treat specific cardiac lesions. It combines general measures with drug therapy.

- ***Non-Pharmacological Measures***

A heart-healthy diet supports drug therapy. Omega-3 fatty acids have anti-inflammatory effects because they compete with the omega-6 fatty acid arachidonic acid, the precursor of pro-inflammatory eicosanoids such as prostaglandins [25]. Limiting sodium helps control fluid retention and blood pressure in children with edema or lupus nephritis, and avoiding alcohol prevents interactions with medication.

An international task force recommends physical activity for all people with SLE, after medical evaluation when needed. The type, frequency, and intensity of activity should match each patient's abilities and comorbidities, and exercise programs should combine aerobic and resistance training under professional supervision where possible.

Reported benefits include better aerobic capacity, muscle strength, and fatigue [26]. Regular follow-up allows clinicians to monitor disease activity, adjust treatment, and detect adverse drug effects early, and children who receive systemic glucocorticoids need regular checks of linear growth [20].

- ***Pharmacological Therapy***

Nonsteroidal anti-inflammatory drugs (NSAIDs) inhibit cyclooxygenase, the enzyme that produces prostaglandins, and so relieve pain and inflammation. The ESC guidelines name aspirin or another NSAID, combined with colchicine, as first-line treatment for acute pericarditis [11], and NSAIDs are among the first-line drugs for lupus pericarditis [27]. They can cause gastrointestinal injury, kidney dysfunction, and hypertension [28], adverse effects that matter in children with lupus nephritis.

Hydroxychloroquine (HCQ) modulates the immune response and dampens inflammation. The 2023 EULAR recommendations advise HCQ for all patients with lupus at a target dose of 5 mg/kg of real body weight per day [29], and the SHARE recommendations make HCQ standard therapy for every child with lupus [20]. Patients with SLE who take HCQ show reduced platelet activation and healthier vascular function [30]. The risk of retinal toxicity grows with dose and duration of use, so prescribers should keep the daily dose at or below 5 mg/kg of real body weight and arrange regular retinal screening [31].

Glucocorticoids bring inflammation under rapid control. Clinicians adjust oral prednisone to disease severity, and for severe organ disease, including lupus nephritis and serositis, they often start with intravenous methylprednisolone pulses before switching to oral therapy. Prolonged use impairs growth and causes obesity, hypertension, and dyslipidemia, so the dose should come down to the smallest amount that keeps the disease controlled. In adults, EULAR advises maintenance doses of 5 mg/day prednisone equivalent or less, with withdrawal when possible [29]. If the prednisone dose cannot be reduced in a child, the SHARE recommendations advise adding a disease-modifying drug [20].

Immunosuppressive agents control organ-threatening disease and spare glucocorticoids. For active lupus nephritis, EULAR names glucocorticoids, mycophenolate, and low-dose intravenous cyclophosphamide as anchor drugs, with belimumab or calcineurin inhibitors as add-on options. Maintenance therapy and particular organ manifestations call for azathioprine, methotrexate, or a calcineurin inhibitor such as cyclosporine, and clinicians reserve cyclophosphamide and rituximab for organ-threatening and refractory disease [20,29].

Anticoagulants prevent the formation and extension of blood clots. Warfarin lowers the hepatic production of vitamin K-dependent coagulation factors [32]. Heparin takes effect at once: it binds antithrombin and speeds its neutralization of thrombin and factor Xa [33]. In SLE, anticoagulation serves patients with thrombotic events, above all those with antiphospholipid syndrome [29].

Supportive therapy addresses the cardiovascular and renal consequences of the disease. In lupus nephritis, raised blood pressure and urinary protein loss respond to antihypertensive treatment, with drugs that block the renin–angiotensin system, such as angiotensin-converting enzyme inhibitors and angiotensin receptor blockers, as the preferred agents. Diuretics relieve fluid overload, and kidney failure requires kidney replacement therapy [29].

CONCLUSION

Cardiac involvement in SLE can affect the pericardium, myocardium, valves, conduction system, and coronary vessels. Immune-complex deposition, endothelial activation, excess type I interferon, neutrophil extracellular traps, and antiphospholipid antibodies explain much of this damage. Many lesions cause no symptoms, so ECG and echocardiography at diagnosis, as the SHARE recommendations advise, together with periodic reassessment, form the basis of early detection in children. Treatment rests on HCQ for every patient, glucocorticoids at the smallest dose that controls the disease, immunosuppressive agents for organ-threatening disease, and anticoagulation when thrombosis occurs, supported by cardiovascular and renal care and tailored exercise. Pediatric data from Southeast Asia remains scarce, and prospective multicenter studies would clarify the frequency, determinants, and outcomes of cardiac involvement in cSLE.

Conflict of Interest

The authors declare no conflict of interest.

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REFERENCES

[1] Hoi, A., Igel, T., Mok, C. C., & Arnaud, L. (2024). Systemic lupus erythematosus. *The Lancet*, *403*(10441), 2326–2338. https://doi.org/10.1016/S0140-6736(24)00398-2

[2] Tang, S. P., Lim, S. C., & Arkachaisri, T. (2021). Childhood-onset systemic lupus erythematosus: Southeast Asian perspectives. *Journal of Clinical Medicine*, *10*(4), 559. https://doi.org/10.3390/jcm10040559

[3] Tincani, A., Rebaioli, C. B., Taglietti, M., & Shoenfeld, Y. (2006). Heart involvement in systemic lupus erythematosus, anti-phospholipid syndrome and neonatal lupus. *Rheumatology*, *45*(Suppl 4), iv8–iv13. https://doi.org/10.1093/rheumatology/kel308

[4] Alghareeb, R., Hussain, A., Maheshwari, M. V., Khalid, N., & Patel, P. D. (2022). Cardiovascular complications in systemic lupus erythematosus. *Cureus*, *14*(7), e26671. https://doi.org/10.7759/cureus.26671

[5] Guevara, J. P., Clark, B. J., & Athreya, B. H. (2001). Point prevalence of cardiac abnormalities in children with systemic lupus erythematosus. *The Journal of Rheumatology*, *28*(4), 854–859.

[6] Sasaki, J., Sendi, P., Hey, M. T., Evans, C. J., Sasaki, N., & Totapally, B. R. (2022). The epidemiology and outcome of pericardial effusion in hospitalized children: A national database analysis. *The Journal of Pediatrics*, *249*, 29–34. https://doi.org/10.1016/j.jpeds.2022.07.005

[7] Chen, Y. F., Hsieh, M. R., Chang, C. T., Tsai, P. H., & Fang, Y. F. (2022). Exploring the risk factors for poor survival in lupus pericarditis patients: A retrospective cohort study. *Journal of Clinical Medicine*, *11*(18), 5473. https://doi.org/10.3390/jcm11185473

[8] Kim, G., Levy, D. M., Nicolson, D., Minn, S., Knight, A., Hiraki, L. T., Lynch, A., Jean-St-Michel, E., Ashkanase, J., & Jeewa, A. (2024). Severe inflammatory heart disease in children with lupus: A case series. *CJC Pediatric and Congenital Heart Disease*, *3*, 161. https://doi.org/10.1016/j.cjcpc.2024.05.005

[9] Justiz Vaillant, A. A., Sabir, S., & Jan, A. (2024). Physiology, immune response. In *StatPearls*. StatPearls Publishing.

[10] Kuhn, A., & Landmann, A. (2023). Systemic lupus erythematosus. In *European handbook of dermatological treatment* (pp. 585–598). Springer. https://doi.org/10.1007/978-3-031-15130-9_54

[11] Adler, Y., Charron, P., Imazio, M., Badano, L., Barón-Esquivias, G., Bogaert, J., Brucato, A., Gueret, P., Klingel, K., Lionis, C., Maisch, B., Mayosi, B., Pavie, A., Ristić, A. D., Sabaté Tenas, M., Seferovic, P., Swedberg, K., & Tomkowski, W. (2015). 2015 ESC Guidelines for the diagnosis and management of pericardial diseases. *European Heart Journal*, *36*(42), 2921–2964. https://doi.org/10.1093/eurheartj/ehv318

[12] Aringer, M., Costenbader, K., Daikh, D., Brinks, R., Mosca, M., Ramsey-Goldman, R., Smolen, J. S., Wofsy, D., Boumpas, D. T., Kamen, D. L., Jayne, D., Cervera, R., Costedoat-Chalumeau, N., Diamond, B., Gladman, D. D., Hahn, B., Hiepe, F., Jacobsen, S., Khanna, D., . . . Johnson, S. R. (2019). 2019 European League Against Rheumatism/ American College of Rheumatology classification criteria for systemic lupus erythematosus. *Arthritis & Rheumatology*, *71*(9), 1400–1412. https://doi.org/10.1002/art.40930

[13] Zeng, Y., Sun, R., Li, X., Liu, M., Chen, S., & Zhang, P. (2016). Pathophysiology of valvular heart disease. *Experimental and Therapeutic Medicine*, *11*(4), 1184–1188. https://doi.org/10.3892/etm.2016.3048

[14] Ibrahim, A. M., & Siddique, M. S. (2023). Libman-Sacks endocarditis. In *StatPearls*. StatPearls Publishing. https://www.ncbi.nlm.nih.gov/books/NBK532864/

[15] Shapiro, R. F., Gamble, C. N., Wiesner, K. B., Castles, J. J., Wolf, A. W., Hurley, E. J., & Salel, A. F. (1977). Immunopathogenesis of Libman-Sacks endocarditis: Assessment by light and immunofluorescent microscopy. *Annals of the Rheumatic Diseases*, *36*(6), 508–516. https://doi.org/10.1136/ard.36.6.508

[16] Zuily, S., Regnault, V., Selton-Suty, C., Eschwège, V., Bruntz, J. F., Bode-Dotto, E., De Maistre, E., Dotto, P., Perret-Guillaume, C., Lecompte, T., & Wahl, D. (2011). Increased risk for heart valve disease associated with antiphospholipid antibodies in patients with systemic lupus erythematosus: Meta-analysis of echocardiographic studies. *Circulation*, *124*(2), 215–224. https://doi.org/10.1161/CIRCULATIONAHA.111.028522

[17] Mohamed, A. A. A., Hammam, N., El Zohri, M. H., & Gheita, T. A. (2019). Cardiac manifestations in systemic lupus erythematosus: Clinical correlates of subclinical echocardiographic features. *BioMed Research International*, *2019*, 2437105. https://doi.org/10.1155/2019/2437105

[18] Petri, M., Orbai, A. M., Alarcón, G. S., Gordon, C., Merrill, J. T., Fortin, P. R., Bruce, I. N., Isenberg, D., Wallace, D. J., Nived, O., Sturfelt, G., Ramsey-Goldman, R., Bae, S. C., Hanly, J. G., Sánchez-Guerrero, J., Clarke, A., Aranow, C., Manzi, S., Urowitz, M., . . . Magder, L. S. (2012). Derivation and validation of the Systemic Lupus International Collaborating Clinics classification criteria for systemic lupus erythematosus. *Arthritis & Rheumatism*, *64*(8), 2677–2686. https://doi.org/10.1002/art.34473

[19] Stojan, G., Fang, H., Magder, L., & Petri, M. (2013). Erythrocyte sedimentation rate is a predictor of renal and overall SLE disease activity. *Lupus*, *22*(8), 827–834. https://doi.org/10.1177/0961203313492578

[20] Groot, N., de Graeff, N., Avcin, T., Bader-Meunier, B., Brogan, P., Dolezalova, P., Feldman, B., Kone-Paut, I., Lahdenne, P., Marks, S. D., McCann, L., Ozen, S., Pilkington, C., Ravelli, A., van Royen-Kerkhof, A., Uziel, Y., Vastert, B., Wulffraat, N., Kamphuis, S., & Beresford, M. W. (2017). European evidence-based recommendations for diagnosis and

treatment of childhood-onset systemic lupus erythematosus: The SHARE initiative. *Annals of the Rheumatic Diseases*, *76*(11), 1788–1796. https://doi.org/10.1136/annrheumdis-2016-210960

[21] Gladman, D. D., Ibañez, D., & Urowitz, M. B. (2002). Systemic lupus erythematosus disease activity index 2000. *The Journal of Rheumatology*, *29*(2), 288–291.

[22] Sattar, Y., & Chhabra, L. (2023). Electrocardiogram. In *StatPearls*. StatPearls Publishing.

[23] AlTwajery, M., AlMane, W., & Al-Mayouf, S. M. (2018). Electrocardiographic disturbances in children with systemic lupus erythematosus. *International Journal of Pediatrics and Adolescent Medicine*, *5*, 127–130. https://doi.org/10.1016/j.ijpam.2018.12.002

[24] Mohamed, A. A., Arifi, A. A., & Omran, A. (2010). The basics of echocardiography. *Journal of the Saudi Heart Association*, *22*(2), 71–76. https://doi.org/10.1016/j.jsha.2010.02.011

[25] Simopoulos, A. P. (2002). Omega-3 fatty acids in inflammation and autoimmune diseases. *Journal of the American College of Nutrition*, *21*(6), 495–505. https://doi.org/10.1080/07315724.2002.10719248

[26] Blaess, J., Geneton, S., Goepfert, T., Appenzeller, S., Bordier, G., Davergne, T., Fuentes, Y., Haglo, H., Hambly, K., Kinnett-Hopkins, D., Su, K. Y., Legge, A., Li, L., Mak, A., Padjen, I., Sciascia, S., Sheikh, S. Z., Soriano-Maldonado, A., Ugarte-Gil, M. F., . . . Arnaud, L. (2024). Recommendations for physical activity and exercise in persons living with systemic lupus erythematosus (SLE): Consensus by an international task force. *RMD Open*, *10*(2), e004171. https://doi.org/10.1136/rmdopen-2024-004171

[27] Ratri, A. K., Alsagaff, M. Y., & Pudy Asmarawati, T. (2018). Acute pericarditis in patient with systemic lupus erythematosus: A case report. *Indonesian Journal of Cardiology*, *39*(1), 32–43. https://doi.org/10.30701/ijc.v39i1.793

[28] Bindu, S., Mazumder, S., & Bandyopadhyay, U. (2020). Non-steroidal anti-inflammatory drugs (NSAIDs) and organ damage: A current perspective. *Biochemical Pharmacology*, *180*, 114147. https://doi.org/10.1016/j.bcp.2020.114147

[29] Fanouriakis, A., Kostopoulou, M., Andersen, J., Aringer, M., Arnaud, L., Bae, S.-C., Boletis, J., Bruce, I. N., Cervera, R., Doria, A., Dörner, T., Furie, R. A., Gladman, D. D., Houssiau, F. A., Inês, L. S., Jayne, D., Kouloumas, M., Kovács, L., Mok, C. C., . . . Boumpas, D. T. (2024). EULAR recommendations for the management of systemic lupus erythematosus: 2023 update. *Annals of the Rheumatic Diseases*, *83*(1), 15–29. https://doi.org/10.1136/ard-2023-224762

[30] Cornwell, M. G., Luttrell-Williams, E. S., Golpanian, M., El Bannoudi, H., Myndzar, K., Izmirly, P., Belmont, H. M., Katz, S., Smilowitz, N. R., Engel, A., Clancy, R., Ruggles, K., Buyon, J. P., & Berger, J. S. (2021). Hydroxychloroquine is associated with lower platelet activity and improved vascular health in systemic lupus erythematosus. *Lupus Science & Medicine*, *8*(1), e000475. https://doi.org/10.1136/lupus-2021-000475

[31] Marmor, M. F., Kellner, U., Lai, T. Y. Y., Melles, R. B., & Mieler, W. F. (2016). Recommendations on screening for chloroquine and hydroxychloroquine retinopathy (2016 revision). *Ophthalmology*, *123*(6), 1386–1394. https://doi.org/10.1016/j.ophtha.2016.01.058

[32] Patel, S., Singh, R., Preuss, C. V., & Patel, N. (n.d.). Warfarin. In *StatPearls*. StatPearls Publishing. https://www.ncbi.nlm.nih.gov/books/NBK470313/

[33] Hirsh, J., Warkentin, T. E., Shaughnessy, S. G., Anand, S. S., Halperin, J. L., Raschke, R., Granger, C., Ohman, E. M., & Dalen, J. E. (2001). Heparin and low-molecular-weight heparin: Mechanisms of action, pharmacokinetics, dosing, monitoring, efficacy, and safety. *Chest*, *119*(1 Suppl), 64S–94S. https://doi.org/10.1378/chest.119.1_suppl.64S