CARDIAC SARCOIDOSIS

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Cardiac involvement in patients with sarcoidosis is being increasingly recognised and is associated with poor prognosis. Although environmental and genetic factors have been implicated in its pathogenesis, the aetiology of cardiac sarcoidosis remains obscure. Clinical manifestations include advanced heart block, arrhythmias, and congestive heart failure. To date, cardiac sarcoidosis has been extremely difficult to diagnose clinically because the clinical manifestations are non-specific, and the sensitivity and specificity of diagnostic modalities are limited. The optimal management of cardiac sarcoidosis has not been well defined. Although corticosteroids remain the mainstay of treatment, there is little evidence for the optimal initiation, dosage, or duration of therapy. This article will update the reader on the clinical manifestations and pathophysiology of cardiac sarcoidosis, with a special focus on recent diagnostic and therapeutic modalities.

HISTORICAL PERSPECTIVE

Although Jonathan Hutchinson described the first case of cutaneous sarcoid in 1869,^{w1} the illness was named by Boeck, a Norwegian dermatologist, who in 1899 described nodular skin lesions of epithelioid cells. He thought that these cells resembled sarcoma cells; hence the designation “sarcoid”.^{w2} It took an extra 60 years to achieve recognition that sarcoid can involve the heart. Bernstein, in 1929, was the first to recognise cardiac involvement in a patient with systemic sarcoidosis.^{w3} In 1952 Longcope and Freiman were the first to describe myocardial involvement in 20% of 92 necropsied cases of sarcoidosis.^{w4}

EPIDEMIOLOGY

Sarcoidosis most commonly involves granuloma formation in the lungs. Other commonly involved organ systems include the lymph nodes, skin, eyes, heart, and the nervous, musculoskeletal, renal, and endocrine systems. The disease is more commonly seen in young and middle aged adults. In the USA, African Americans have a three- to fourfold greater risk for disease compared with whites. Estimates of the prevalence of sarcoidosis range from 10.9 per 100 000 population for whites to 35.5 per 100 000 for blacks. In Europe, Scandinavians have one of the highest incidence rates at 50–60 cases per 100 000 population.¹ Myocardial involvement occurs in at least 25% of patients with sarcoidosis in the USA, and accounts for as many as 13–25% of deaths from sarcoidosis.^{2 w5} In Japan, sarcoid heart disease is more common and responsible for as many as 85% of deaths from sarcoidosis.^{w6} Ante-mortem diagnosis of cardiac sarcoidosis is exceptionally challenging because only 40–50% of patients with cardiac sarcoidosis at necropsy have clinical evidence of myocardial involvement during their lifetime.²

PATHOGENESIS

The aetiology of sarcoidosis remains obscure. Infectious (*Mycobacterium tuberculosis*, *Mycoplasma* species, *Corynebacteria* species, spirochetes) and environmental agents (aluminium, pollen, clay, talc) have been implicated as potential antigens. These antigens, non-self or self, are thought to trigger primarily the helper inducer T cells leading to the formation of granuloma lesions. Early in the disease, sarcoid infiltrates mainly consist of mononuclear phagocytes and CD4 positive T cells with a T helper type I response, secreting interleukin-2 and interferon- γ . At a later stage of lesion evolution, there is a shift in the cytokine profile to that of T helper type 2 response which has been demonstrated during the fibroproliferative phase of the granuloma and is believed to exert anti-inflammatory effects and result in tissue scarring (fig 1). Furthermore, high concentrations of interleukin-6 were found in the circulation at the onset of the disease and before the initiation of immunosuppressive therapy, but not thereafter. Interleukin-6 is thought to be involved in the maintenance of inflammation by inducing the proliferation of T cells.³

Genetic factors are also believed to contribute to the pathogenesis of cardiac sarcoidosis. Sarcoidosis is more likely to occur in twins if they are monozygotic.^{w7} Certain HLA typing has been associated with sarcoidosis. A positive association with cardiac sarcoidosis has been reported

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Figure 1 Pathogenesis of sarcoidosis. When the antigen receptor of the T cell is ligated by antigen, two stereotypical responses can be elicited. Early in the disease course, activated T cells differentiate into the type 1 helper T (Th1) effectors cells and begin producing the macrophage activating cytokine interferon- γ (INF- γ), leading to inflammation. Regulatory cytokines of the type 2 helper (Th2) pathway modulate the process by secreting anti-inflammatory cytokines (such as interleukin-10 and transforming growth factor β), contributing to the formation of tissue scarring.

with HLA-DQB1*0601.^{w8} ACE gene polymorphism as well as tumour necrosis factor α promoter gene polymorphism have also been evaluated as a potential marker for an increased risk of sarcoidosis.^{w9 w10}

PATHOLOGIC FEATURES

No portion of the heart is immune to infiltration by sarcoid granulomas. The granulomas may involve the pericardium, myocardium, and endocardium, but of the three, the myocardium is, by far, the one most frequently involved. The predominant sites of myocardial involvement, in decreasing order of frequency, are the left ventricular free wall and papillary muscles, the basal aspect of the ventricular septum, the right ventricular free wall, and the atrial walls.⁴

Samples of myocardium involved with sarcoidosis reveal the presence of numerous lymphocytes located at the border zones around the granulomas. A dense band of fibroblasts, collagen fibres, and proteoglycans usually encase this aggregate of inflammatory cells (fig 2).⁵

CLINICAL MANIFESTATIONS

The clinical sequelae of cardiac sarcoidosis range from asymptomatic conduction abnormalities to fatal ventricular arrhythmias, depending upon the location and extent of granulomatous inflammation.

Complete heart block is the most common finding in patients with clinically evident cardiac sarcoidosis and is reported in 23–30% of patients.⁴ First degree heart block and bundle branch block also often occur, due to involvement of the basal septum by scar tissue or granulomas or the involvement of the nodal artery causing ischaemia in the conduction system.^{w11}

Sarcoid granulomas in the ventricular myocardium can become foci for abnormal automaticity, increasing the likelihood of re-entrant tachyarrhythmias. Ventricular tachycardia (VT) is the most frequent arrhythmia noted in cardiac

Figure 2 Samples of myocardium involved with sarcoidosis. Panel A is a low power micrograph showing non-caseating, multinucleated giant cell granuloma located in the subendocardium from a patient who presented with congestive heart failure. Trichrome stain was used in panel B rendering a dense band of collagen fibres, encasing aggregate of granulomas and inflammatory cells, blue.

sarcoidosis with a reported incidence of 23%.⁶ Roberts and colleagues found that sudden death caused by arrhythmia is the terminal event in 67% of sarcoid heart disease deaths.⁴ Supraventricular arrhythmias (for example, atrial flutter,

fibrillation, and paroxysmal atrial tachycardia) may occur but are less common (15–17%). Atrial arrhythmias are mostly the result of atrial dilatation and/or pulmonary involvement rather than the result of atrial granulomas.^{4 w11}

Congestive heart failure is another manifestation and may be attributed to widespread infiltration of the myocardium, ventricular aneurysms, rhythm disturbances, cor pulmonale caused by pulmonary hypertension, valvar regurgitation, or a combination of these processes. Progressive congestive cardiac failure has been shown to be the cause of death in 25% of patients with cardiac sarcoidosis, making it the second most frequent cause of death, after sudden death.^{4 w12}

Other clinical manifestations of sarcoid heart disease include chest pain, electrocardiographic changes that may mimic transmural myocardial infarction, and pericardial abnormalities such as pericardial effusion, constrictive pericarditis, or even tamponade. Pericardial effusions are not uncommon (3–19%) in sarcoid, but rarely tend to tamponade.^{4 w13}

DIAGNOSIS

Cardiac involvement in sarcoidosis is extremely difficult to diagnose clinically. The Japanese Ministry of Health and Welfare published in 1993 guidelines for diagnosing cardiac sarcoidosis (table 1).⁷ However, the role of these guidelines in establishing the diagnosis of cardiac sarcoidosis has not been clearly validated.

Endomyocardial biopsy

Transvenous endomyocardial biopsy, in spite of its specificity, may lack sensitivity as a result of sampling error because myocardial infiltration by sarcoid is usually patchy or focal. Previous pathologic and morphologic studies indicated that myocardial distribution of sarcoid granulomas tends to be basal and the endomyocardial biopsy specimens are usually obtained from the apical septum.^{w14} In one postmortem study of hearts with confirmed sarcoidosis, the likelihood of diagnosing sarcoidosis on the basis of right ventricular endomyocardial biopsy specimens was 63% and on the basis of left ventricular specimens was 47%.⁶

Electrocardiography

Electrocardiography is widely used to detect cardiac involvement in patients with sarcoidosis. As many as a half of all

living patients with systemic sarcoidosis will have electrocardiographic abnormalities, including repolarisation abnormalities and alterations in rhythm and conduction.^{w15} However, electrocardiography remains a poorly sensitive exam since the significance of these alterations and their relation to cardiac lesions and the patients' symptoms are often unclear. It is difficult to predict based on electrocardiographic findings which patients with sarcoidosis may be more prone to develop life threatening arrhythmias.

Echocardiography

Echocardiographic abnormalities have been reported in patients with cardiac sarcoidosis but the prevalence, spectrum, and clinical significance of echocardiographic findings are unknown. Abnormalities seen on transthoracic echocardiography, which include septal thinning, left ventricular regional systolic dysfunction, pericardial effusion, ventricular aneurysms, left ventricular diastolic dysfunction, and valvar abnormalities, are usually seen in advanced disease and can be detected in only 14% of patients with systemic sarcoidosis and cardiac involvement.⁸ Cardiac lesions may also produce an increase in the thickness of the interventricular septum, mimicking hypertrophic cardiomyopathy. This suggests that two dimensional echocardiography may not be sensitive enough to detect mild or small localised abnormalities, which may occur in the early stages of cardiac involvement. Recently, ultrasonic tissue characterisation with integrated backscatter, which measures acoustic properties of the myocardium in the basal septum, has been shown to be potentially more sensitive (75%) than two dimensional echocardiography in early diagnosis of cardiac involvement in patients with sarcoidosis.^{w16} In one case report, Hourigan and colleagues suggest that transoesophageal echocardiography may increase the detection rate of cardiac involvement in patients with systemic sarcoidosis.^{w17} Ultimately, the role of transoesophageal echocardiography in establishing the diagnosis of cardiac sarcoidosis awaits the results of further longitudinal studies.

Radionuclide examinations Thallium-201 scintigraphy

Several reports have been published regarding the usefulness of radionuclide myocardial scanning in patients with suspected cardiac sarcoidosis (table 2). Resting thallium-201 myocardial scintigraphy typically shows segmental areas of decreased uptake in the ventricular myocardium. The meaning of these defects remains unclear and lacks correlation with myocardial histology. These defects may occur with myocardial ischaemia as well as other causes of cardiac infiltration and cardiomyopathy. Therefore, it is necessary to exclude these diseases by history taking, ECG, echocardiography, or coronary angiography. A phenomenon, called *reverse distribution*, may be useful in differentiating cardiac sarcoidosis from coronary ischaemic disease—hence, improving specificity of 201 thallium scintigraphy. In patients with suspected myocardial sarcoid, the focal defects detected in the resting phase of thallium scanning disappear or decrease in size during thallium stress imaging or after dipyridamole infusion.⁹ These results are quite different from those observed in patients with coronary artery disease, in which defects are unchanged or enhanced after exercise or intravenous dipyridamole. The most likely explanation of this phenomenon is the presence of focal reversible microvascular constriction in coronary arterioles surrounding

Table 1 Guidelines for diagnosing cardiac sarcoidosis (from the Japanese Ministry of Health and Welfare)

1. Histologic diagnosis group

Cardiac sarcoidosis is confirmed when histologic analysis of operative or endomyocardial biopsy specimens demonstrates epithelioid granuloma without caseating granuloma

2. Clinical diagnosis group

In patients with a histologic diagnosis of extracardiac sarcoidosis, cardiac sarcoidosis is suspected when item (a) and one or more of items (b) though (e) are present:

- (a) Complete right bundle branch block, left axis deviation, atrioventricular block, VT, premature ventricular contraction ($\geq$ Lowen 2), or abnormal Q or ST-T change on the ECG or ambulatory ECG
- (b) Abnormal wall motion, regional wall thinning, or dilatation of the left ventricle
- (c) Perfusion defect by thallium-201 myocardial scintigraphy or abnormal accumulation by gallium-67 or technetium-99m myocardial scintigraphy
- (d) Abnormal intracardiac pressure, low cardiac output, or abnormal wall motion or depressed ejection fraction of the left ventricle
- (e) Interstitial fibrosis or cellular infiltration over moderate grade even if the findings are non-specific

VT, ventricular tachycardia.

sarcoid granulomas.^{w18} Nonetheless, thallium scintigraphy should be interpreted with great caution, and should not be used indiscriminately to screen for the presence of cardiac involvement in sarcoid patients without cardiac symptoms because non-specific results can occur. Kinney and colleagues concluded that thallium myocardial perfusion scan abnormalities are not significantly associated with survival in patients with sarcoidosis and cannot reliably be used to diagnose sarcoid heart disease.^{w19}

Gallium-67 scintigraphy

Gallium-67 scintigraphy is also used to diagnose myocardial involvement in sarcoidosis. Gallium-67 accumulates only in areas of active inflammation, so the test is positive only when the disease is active. Okayama and colleagues reported that when thallium showed myocardial defects, a gallium heart uptake did not add more diagnostic information but was predictive of the efficacy of corticosteroid treatment.¹⁰ Lack of gallium-67 uptake in the region with thallium-201 defect may indicate the lesion of myocardial involvement of sarcoidosis without active inflammation and may therefore predict a poor response to corticosteroids. It is often difficult to visualise abnormal nuclide uptake into the myocardium by gallium single photon emission computed tomography (SPECT) scanning because of the inability to distinguish between gallium uptake in other organs from that in the myocardium. Nakazawa and colleagues lately described that dual SPECT using gallium-67 and technetium-99m can improve remarkably the accuracy and spatial resolution of gallium-67 SPECT scanning in the diagnosis of cardiac sarcoidosis.^{w20}

Other radionuclide studies with technetium-99m and iodine-123-labeled 15-(p-iodophenyl)-3R,S-methylpenta-decanoic acid (BMIPP) scintigraphy have detected abnormalities in more patients with confirmed sarcoidosis and clinical suspicion of myocardial involvement as compared to thallium SPECT (table 2). Further studies are nevertheless still needed to provide definitive proof of these advantages.

Positron emission tomography

The usefulness of cardiac positron emission tomography (PET) for detection of myocardial involvement with sarcoidosis has been studied. 18F-fluorodeoxyglucose (FDG) has been observed to be accumulated by inflammatory cells—namely, leucocytes, lymphocytes, and macrophages. In pulmonary sarcoidosis, 18F-FDG uptake has been observed in the lung and bilateral hilar lymph nodes and found to be concordant with histologic and inflammatory activities. Uptake has been shown to decrease notably after high dose steroid treatment.^{w21} Yamagishi and colleagues demonstrated that 18F-FDG PET accumulates in the myocardium of patients with cardiac sarcoidosis, as it does in pulmonary sarcoidosis.^{w22} 18F-FDG PET demonstrated higher sensitivity for the detection of myocardial involvement than thallium-201 SPECT and gallium-67 scintigraphy (table 2). The specificity of 18F-FDG PET for diagnosis of cardiac sarcoidosis is yet to be confirmed as heterogeneous myocardial FDG uptake was also observed in patients with idiopathic dilated cardiomyopathy and found to correlate with poor prognosis.

Magnetic resonance imaging

Experience with magnetic resonance imaging (MRI) to diagnose or monitor myocardial sarcoidosis is evolving. Cardiac sarcoidosis has been described as producing zones

Cardiac imaging in sarcoidosis: key points

- ▶ Two dimensional echocardiography is not sensitive or specific enough to detect early or small localised myocardial involvement in sarcoidosis
- ▶ Technetium-99m is more sensitive than thallium-201 SPECT. Both modalities exhibit the “reverse distribution” phenomenon during stress imaging or after dipyridamole infusion
- ▶ Gallium-67 heart uptake predicts a better response to corticosteroid treatment. Dual gallium-67 and technetium-99m SPECT appears to improve the accuracy of gallium-67 SPECT scanning
- ▶ Contrast enhanced magnetic resonance imaging and 18F-FDG PET are most sensitive, and findings seem to correlate with disease activity

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of thinning and segmental myocardial wall motion abnormalities with increased intramyocardial signal intensity more pronounced on T2 weighted images because of the oedema associated with inflammation and granulomatous lesions. These images can be enhanced with gadolinium-diethylene-triamine pentaacetic acid (fig 3). The pattern of enhancement is not typical of myocardial infarction, in that the increased signal intensity manifests mostly in the mid portion of the myocardium and epicardium, and not in the endocardium. Vignaux and colleagues emphasised the usefulness of contrast enhanced MRI (CMR) in the early detection of cardiac sarcoidosis and evaluation of response to steroid treatment.^{w27} Follow up studies showed that the enhanced areas were notably diminished in size and intensity after corticosteroid treatment. Normalisation of the enhancement correlated with clinical improvement and clearing of sarcoidosis.^{w28 w29} When comparing the diagnostic value of CMR with that of thallium-201 and echocardiography, CMR is more sensitive in detecting early myocardial involvement in patients with systemic sarcoidosis and no clinical or electrical cardiac manifestations. Recently, Smedema and colleagues reported that the sensitivity and specificity of CMR were 100% and 78%, respectively, for the diagnosis of cardiac involvement in patients with cardiac sarcoidosis determined using the Japanese Ministry of Health and Welfare guidelines.¹⁴

Considering the superior anatomical and functional resolution of CMR, new diagnostic guidelines need to be compiled that include CMR for the diagnosis of cardiac sarcoidosis. CMR can also be used as an accurate guide to obtaining an endomyocardial biopsy specimen. The most significant drawback of CMR is that patients with a pacemaker and/or automatic implantable cardioverter-defibrillator (ICD) will not be able to take advantage of it. Further multicentre studies are still required to determine the clinical significance of CMR abnormalities in patients with no clinical or scintigraphic evidence of cardiac sarcoidosis.

PROGNOSIS

The prognosis of sarcoid heart disease is not well defined. Early necropsy series of 113 patients concluded that survival in most patients with symptomatic cardiac sarcoidosis was limited to about two years.⁴ Substantially better outcomes were noted in later studies where five year survival was 40–60%.^{w30 w31} Whether the improvement in prognosis was due to early disease recognition (lead time bias) or a relatively milder form of cardiac sarcoidosis versus early institution of

Table 2 Studies of various radionuclide examinations for the detection of myocardial involvement in patients with sarcoidosis

Study	Patient groups	Radionuclide exam	Sensitivity (%)
Kaminaga <i>et al</i> 2004 ^{w23}	6 patients with pathologically proven cardiac sarcoidosis	BMIPP	75
Okumura <i>et al</i> 2004 ¹¹	11 patients with cardiac sarcoidosis diagnosed according to the JMHW guidelines	Thallium-201	58
		18F-FDG	100
		Technetium-99m	64
Yamagishi <i>et al</i> 2003 ^{w22}	17 patients with cardiac sarcoidosis diagnosed according to the JMHW guidelines	Gallium-67	36
		18F-FDG	82
		Thallium-201	35
Eguchi <i>et al</i> 2000 ^{w24}	6 patients with pathologically proven cardiac sarcoidosis	Gallium-67	18
Okumura <i>et al</i> 1999 ^{w25}	10 patients with systemic sarcoidosis and cardiac complications	Technetium-99m	67
		18F-FDG	100
		Technetium-99m	80
		Gallium-67	50
Okayama <i>et al</i> 1995 ¹⁰	25 cardiac asymptomatic patients with systemic sarcoidosis	Thallium-201	24
Le Guludec <i>et al</i> 1994 ¹²	37 patients with systemic sarcoidosis and clinical and/or electrocardiographic cardiac abnormalities	Technetium-99m	65
		Thallium-201	46
Kinney <i>et al</i> 1990 ^{w19}	52 cardiac asymptomatic patients with systemic sarcoidosis	Thallium-201	44
Haywood <i>et al</i> 1982 ^{w26}	30 patients with systemic sarcoidosis and clinical and/or electrocardiographic cardiac abnormalities	Thallium-201	37
Kinney <i>et al</i> 1980 ¹³	44 cardiac asymptomatic patients with systemic sarcoidosis	Thallium-201	32

BMIPP, iodine-123-labelled 15-(p-iodophenyl)-3R,S-methylpentadecanoic acid; CS, cardiac sarcoidosis; FDG, 2-fluoro-2-deoxy-D-glucose; JMHW, Japanese Ministry of Health and Welfare.

corticosteroid treatment remains to be determined. Important independent predictors of mortality are New York Heart Association (NYHA) functional class, left ventricular end diastolic diameter, and sustained VT. Patients with preserved left ventricular function have greater survival rates than those with impaired left ventricular function and poor NYHA functional class.¹⁵

TREATMENT

Corticosteroid treatment

There is still controversy about the clinical efficacy and the optimal initial dose and duration of corticosteroid treatment for cardiac sarcoidosis. Corticosteroid treatment may halt the progression of cardiac disease and improve survival; however, it does not seem to reduce the incidence of ventricular arrhythmias.¹⁶ The mechanism of action of steroids in cardiac sarcoidosis is unknown, but it is believed that these agents are capable of slowing the progression of inflammation and

fibrosis through re-establishing a normal TH1/TH2 balance.^{w32} Doses of 60–80 mg of prednisone daily are generally prescribed initially. In one study, the starting dose of 30 mg/day was proven sufficient to improve prognosis.¹⁵ Patients should be re-evaluated after 2–3 months, and if the disease is responding, the dose is tapered gradually to a maintenance level of 10–15 mg per day over a period of six months. If serial evaluations reveal that the disease is controlled, corticosteroids may be tapered further and eventually discontinued. Prerequisites for steroid taper or withdrawal include absence of disease activity, confirmed by radionuclide or CMR imaging, and by serum determinations of angiotensin converting enzyme if values were initially elevated at time of diagnosis. Alternative agents such as antimalarials, methotrexate, and azathioprine may be given to patients who do not respond to corticosteroids or who cannot tolerate their side effects. However, the data supporting efficacy of these alternative agents are largely anecdotal (fig 4).

Antiarrhythmic treatment

Antiarrhythmic treatment and β blockers are also often needed in the management of sarcoid heart disease. There have been no prospective studies evaluating the use of these agents in patients with cardiac sarcoidosis. β Blockers might actually increase the risk of heart block, and amiodarone could exacerbate restrictive lung disease in sarcoidosis. Therefore, the physician must carefully weigh the benefits versus the risks of prescribing these medications.

Pacemakers and defibrillators

Pacemaker implantation may often become necessary if the conduction system is extensively involved. ICD placement for patients with cardiac sarcoidosis has not been thoroughly evaluated. The mechanism of VT in sarcoidosis is re-entry and has different inducibility between the active and inactive phases of sarcoid heart disease in an electrophysiologic study.¹⁷ This makes treatment with corticosteroids less effective in preventing further arrhythmias. In patients with refractory ventricular tachyarrhythmias who are at risk of sudden death, treatment with an ICD, in addition to antiarrhythmic therapy, is mandatory. Some experts would

Figure 3 Gadolinium-diethylenetriamine pentaacetic acid (DTPA) enhanced magnetic resonance imaging in the detection of cardiac sarcoidosis. Cardiac sarcoidosis produces zones of segmental wall thinning that enhances with gadolinium-DTPA (arrow). The pattern of enhancement manifests mostly in the mid portion of the myocardium and is not typical of myocardial infarction.

Figure 4 Suggested treatment algorithm for cardiac sarcoidosis.

also recommend ICD placement in any patient with sarcoidosis and non-sustained VT given that there is a high rate of recurrence of VT despite antiarrhythmic and corticosteroid treatment.^{16–18}

Cardiac transplantation

Cardiac transplantation for cardiac sarcoidosis is rare. It remains, however, a possibility for younger patients with severe end stage irreversible cardiac failure or resistant VT.¹⁹ Recurrent disease in the transplanted heart can occur.²⁰ Other types of surgery may be occasionally required such as correction of mitral valve disease or resection of ventricular aneurysms. A possible association between corticosteroid treatment and formation of ventricular aneurysms has been described.⁴ These aneurysms can certainly promote further arrhythmias, thereby increasing the risk of sudden death. Surgery and cardiac transplantation can be avoided if a diagnosis is made early and corticosteroid treatment is started, preferably before the occurrence of severe systolic dysfunction.

CONCLUSIONS

In spite of recent advances in imaging modalities, early diagnosis of cardiac sarcoidosis remains very challenging. We recommend screening with 18F-FDG PET or CMR for cardiac sarcoidosis in patients in whom the disease is suspected, given the lower diagnostic sensitivity of other available procedures. Early institution of corticosteroid treatment may

improve survival and is recommended whenever the diagnosis of cardiac sarcoidosis is considered. Because of the relatively high risk of sudden cardiac death, especially if ventricular arrhythmias are present, early consideration for implantation of an ICD with pacing capability should be a priority. Future goals are to compare the diagnostic value of PET with CMR and develop new guidelines capable of detecting early myocardial involvement with sarcoidosis and differentiating it from other aetiologies of cardiomyopathy.

Additional references appear on the *Heart* website—<http://www.heartjnl.com/supplemental>

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Treatment of cardiac sarcoidosis: key points

- ▶ Corticosteroids are the first line treatment. They may improve survival; however, they do not reduce the incidence of ventricular arrhythmias
- ▶ Internal cardioverter-defibrillator (ICD) placement is highly recommended in patients with sarcoidosis and history of non-sustained ventricular tachycardia. There have been no studies evaluating the use of antiarrhythmic agents in cardiac sarcoidosis
- ▶ Cardiac transplantation is an option for younger patients. Sarcoidosis is a systemic disease and sarcoid lesions in transplanted cardiac allografts can occur

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 - ▶ While earlier studies report that sarcoidosis does not recur in cardiac allografts, this case report describes the first patient in whom cardiac sarcoidosis recurred in the allograft six months after heart transplantation.

Additional references appear on the Heart website—
<http://www.heartjnl.com/supplemental>