Risk factors for avascular necrosis of bone in patients with systemic lupus erythematosus: Is there a role for antiphospholipid antibodies?

M Y Mok, V T Farewell, D A Isenberg

Abstract

Background—Avascular necrosis of bone (AVN) is a well known complication in patients with systemic lupus erythematosus (SLE).

Objective—to investigate the role of antiphospholipid antibody status (IgM and IgG anticardiolipin antibodies and lupus anticoagulant) with adjustment for corticosteroid use as risk factors for the development of AVN.

Methods—A cohort of 265 patients receiving long term follow up in our SLE clinic from 1978 to 1998 was analysed. Patients with AVN complications were detected and then matched for age, sex, ethnicity, duration of disease, and organ disease with two other patients with SLE. A further 31 patients were chosen at random for the analysis.

Results—Eleven patients had AVN, giving a point prevalence of 4%. There were no significant differences demonstrable in the presence of individual antiphospholipid antibodies (aPL) or their combination between the group with AVN or the two control groups.

Conclusion—Incorporating an adjustment for corticosteroid use we were unable to show a link between the presence of aPL and the development of AVN in patients with SLE.

(Systemic lupus erythematosus (SLE) is an autoimmune rheumatic disease that affects young women, resulting in significant morbidity and mortality. Avascular necrosis of bone (AVN) is a well recognised complication of SLE, which also results in significant morbidity. The clinical course is usually progressive to end stage secondary degenerative changes of the joint causing significant pain and limitation of movement, and reducing the quality of life in these young patients. Histologically, this condition is characterised by subchondral bone necrosis as a result of compromise of end artery supply to the bone. Various non-traumatic causes of the arterial interruption that lead to AVN development in SLE have been looked into in the past two decades. Corticosteroid treatment is considered an important risk factor, but there are reports of patients with SLE complicated by AVN who had never been receiving steroid. Intrinsic vascular factors related to SLE-like vasculitis and vasculopathy have been proposed, and Raynaud’s phenomenon has been reported to be associated with AVN development. In addition, the presence of antiphospholipid antibodies (aPL), a potential risk factor for vascular thrombosis, has been proposed to predispose towards AVN but its role remains controversial. We performed a retrospective case-control study to look into the risk factors, in particular aPL and corticosteroid use, for the development of AVN.

Methods

Selection of index patients and control groups

Records of the cohort of patients with SLE who have attended our lupus clinic at UCL/Middlesex from 1978 to 1998 for a minimum of two years or until death were reviewed, and patients who developed AVN were identified. All patients fulfilled the 1982 revised American Rheumatic Association criteria for the classification of SLE. Index patients with AVN were symptomatic and had the diagnosis of AVN made from plain radiography, bone scan, and/or magnetic resonance imaging scan.

Two control groups were selected. The first comprised two patients with SLE without AVN carefully matched to each of our index patients for age, sex, race, duration of symptoms, age of onset, and organ disease (that is, 22 matched controls). The second control group consisted of patients with SLE selected randomly (that is, 31 unmatched controls).

Demographic data and clinical features

The demographic data of these patients (including their age at study, sex, ethnicity, age at onset of SLE, age at diagnosis of AVN, duration between onset of SLE and diagnosis of AVN), other major systemic manifestations of SLE, autoantibody profile (including anti-nuclear antibodies, anti-dsDNA, extractable nuclear antigen antibodies, aPL including IgM and IgG anticardiolipin antibodies (aCL), and lupus anticoagulant (LAC), activated partial thromboplastin time), other major systemic illnesses, smoking, and drinking habits were recorded.

For patients with AVN, sites of articular disease affected by AVN and information on surgical interventions were recorded. Any bone
mineral density measurement performed at around the time of the development of AVN was also noted. Daily and total cumulative dose of corticosteroid at the development of AVN were calculated as a prednisolone equivalent.

STATISTICAL ANALYSIS
To accommodate the 2:1 matching in this study, the comparison of the patients with AVN with their matched controls was based on conditional logistic regression. This methodology models the probability of AVN as a function of explanatory variables after adjusting for characteristics common to the matched sets. The variables defined were binary indicators of IgM and IgG aCL, a binary indicator for LAC, and a variable which coded cumulative steroid dose. The results of the logistic analyses are summarised as an odds ratios (OR). For a simple binary classification, such as the presence or absence of LAC, an OR compares the odds of AVN for a patient in one class, say those having LAC, with the odds for other patients.

For a continuous measure such as steroid dose, the OR compares the odds of AVN for two patients whose steroid doses differ by one unit. If patients’ times differed by, say, k units, then their odds of AVN would be related by a factor of (OR)^k. The inclusion of steroid dose in the models was undertaken to provide a comparison of aPL status, which was adjusted for any differences in steroid use between the matched pairs that remain after matching for disease duration. The study was not designed to provide a detailed investigation of the effect of steroid use.

The comparison of patients with AVN with the unmatched control group was based on unconditional logistic regression as there is no matching to be considered. The analysis is otherwise similar to that for the matched controls except that an additional adjustment variable—age of SLE diagnosis—was included.

Results
Eleven patients with SLE from our cohort of 265 were found to have AVN complications, giving a point prevalence of 4%. Table 1 summarises the demographic data and clinical features of these patients and table 2 shows their serological characteristics. Their mean age at the time of study was 37.9 (range 27–53) years. All patients were female. Four were white, three Asian, two Afro-Caribbean, and two of mixed ethnicity (one Asian/Afro-Caribbean and the other Asian/white).

The mean age of onset of SLE was 21.3 (range 17–28) years and the mean age of presentation of AVN was 30.5 (range 21–40) years. The average interval between the onset of SLE and the diagnosis of AVN was 9.2 (range 2–23, median 6) years. The femoral head was the most commonly affected site (10/11, 91%) and often affected both femoral heads (7/10, 70%). Patient 1 had AVN affecting an isolated lumbar vertebra (L2), and in another patient (No 6) more than one site—left femoral head, right proximal tibia, and right distal femur—were affected.
distal femur, and right rib—was affected. All these patients were symptomatic at the diagnosis of their AVN and the diagnosis was confirmed by magnetic resonance imaging of the affected region. Three patients (2, 6, 7) needed total hip replacement surgery and one received decompression surgery to her right hip (11).

Other major organ disease of their underlying SLE included glomerulonephritis in 5/11 (45%), pleuritis in 5/11 (45%), cutaneous vasculitis in 4/11 (36%), lymphadenopathy in 4/11 (36%), cerebral lupus in 4/11 (36%), and periarteritis in 3/11 (27%). Raynaud’s phenomenon was found in 3/11 (27%) patients. All patients had lymphopenia and two patients had significant thrombocytopenia.

Patients 1 and 8 had clinical features of secondary antiphospholipid syndrome (APS). Both had recurrent deep vein thrombosis, recurrent miscarriages and central nervous system manifestations (patient 1 had migraine headache, patient 8 had diplopia and limb weakness). All patients had positive antinuclear antibodies. Eight of 11 (73%) patients had positive anti-dsDNA antibodies during any stage of their lupus presentation. Anti-Ro antibodies were found in 5/11 (45%) patients, anti-RNP in 3/11 (27%) patients while anti-La and anti-Sm were both found in 2/11 (18%) patients. Anti-ENA antibodies were not present in three patients.

Two of 11 (18%) patients had positive IgM aCL, 3/11 (27%) patients had positive IgG aCL, and 2/11 (18%) patients had positive LAC (table 3). Two patients had prolonged activated partial thromboplastin time. Five of 11 (45%) patients had coexisting hypertension and 2/11 (18%) patients had hypothyroidism on thyroxine replacement with stable and normal thyroid function tests. All patients with concomitant systemic hypertension were prescribed antihypertensive drugs, and three had fair control, needing frequent readjustment of their treatment. None of the patients had sickle cell trait or disease. Only one patient in our series was a chronic smoker and none of them was a heavy drinker. The bone mineral density around the time of diagnosis of AVN was available in six patients, and five of them (83%) were unremarkable. The mean daily dose of corticosteroid at the time of diagnosis of AVN was 5.4 (range 0–10) mg. Two patients (2 and 8) had already had their corticosteroids reduced and were receiving azathioprine maintenance alone. One patient was receiving a third course of three-monthly intravenous cyclophosphamide infusions for her lupus nephritis. Proteinuria was improving and there was no other clinical evidence of active lupus.

The mean total cumulative corticosteroid doses, as prednisolone equivalents, were 26.6 g, 21.8 g, and 27.2 g for patients with AVN, and the matched and unmatched control groups respectively. Note, that as might be expected for patients matched for disease severity, there was no significant difference in total cumulative corticosteroid dose between the AVN group and their matched controls (p=0.38) or between the AVN group and the unmatched controls (p=0.92).

Table 3 presents the results of including the three binary indicators for IgM, IgG aCL, and LAC, separately and together, in logistic regression models based on the matched and

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Table 2  Serological characteristics and previous steroid use in patients with systemic lupus erythematosus (SLE) complicated by avascular necrosis (AVN) of bone

<table>
<thead>
<tr>
<th>Patient No</th>
<th>ANA</th>
<th>RF</th>
<th>DNA</th>
<th>ENA</th>
<th>aCL</th>
<th>LAC</th>
<th>APTT</th>
<th>Lympocyte count</th>
<th>Platelet count</th>
<th>BMD</th>
<th>Daily dose of prednisolone equivalent (mg) at diagnosis of AVN</th>
<th>Cumulated dose of prednisolone equivalent (mg) at diagnosis of AVN</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1/2560</td>
<td>–ve</td>
<td>+ve</td>
<td>–ve</td>
<td>IgG</td>
<td>+ve</td>
<td>Prolong</td>
<td>Low</td>
<td>Slightly low</td>
<td>5</td>
<td>37 730</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>1/2560</td>
<td>–ve</td>
<td>–ve</td>
<td>Ro</td>
<td>IgM</td>
<td>–ve</td>
<td>Normal</td>
<td>Low</td>
<td>Normal</td>
<td>0</td>
<td>11 200</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>1/640</td>
<td>+ve</td>
<td>+ve</td>
<td>RNP</td>
<td>–ve</td>
<td>–ve</td>
<td>Normal</td>
<td>Low</td>
<td>Normal</td>
<td>10 CTX 3-monthly</td>
<td>46 588</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>1/160</td>
<td>+ve</td>
<td>–ve</td>
<td>RNP</td>
<td>IgM</td>
<td>–ve</td>
<td>Normal</td>
<td>Low</td>
<td>Normal</td>
<td>5</td>
<td>16 800</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>1/1280</td>
<td>+ve</td>
<td>–ve</td>
<td>–ve</td>
<td>–ve</td>
<td>–ve</td>
<td>Normal</td>
<td>Low</td>
<td>Normal</td>
<td>7.5</td>
<td>32 060</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>1/160</td>
<td>+ve</td>
<td>+ve</td>
<td>Sm, Ro</td>
<td>–ve</td>
<td>–ve</td>
<td>Normal</td>
<td>Slightly low</td>
<td>Normal</td>
<td>5</td>
<td>21 586</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>1/160</td>
<td>–ve</td>
<td>+ve</td>
<td>Sm</td>
<td>IgG</td>
<td>–ve</td>
<td>Normal</td>
<td>Low</td>
<td>Normal</td>
<td>10</td>
<td>7 290</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>1/5120</td>
<td>+ve</td>
<td>–ve</td>
<td>RoLa</td>
<td>IgG</td>
<td>+ve</td>
<td>Normal</td>
<td>Normal</td>
<td>ND</td>
<td>0</td>
<td>50 205</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>1/1280</td>
<td>+ve</td>
<td>+ve</td>
<td>Sm, Ro</td>
<td>–ve</td>
<td>–ve</td>
<td>Normal</td>
<td>Low</td>
<td>Normal</td>
<td>4</td>
<td>26 789</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>&gt;1/1280</td>
<td>–ve</td>
<td>–ve</td>
<td>Ro, La, RNP</td>
<td>–ve</td>
<td>–ve</td>
<td>Normal</td>
<td>Low</td>
<td>Normal</td>
<td>7.5</td>
<td>4 760</td>
<td></td>
</tr>
</tbody>
</table>

ANO = antinuclear antibody (tested on Hep 2 cells); APTT = activated partial thromboplastin time; BMD = bone mineral density; CTX = cyclophosphamide; DNA = anti-dsDNA (tested on Crithidia lucidiae); ENA = antibodies to extractable nuclear antigens (tested by ELISA); LAC = lupus anticoagulant; RF = rheumatoid factor; (w) = weak.

Table 3  Logistic regression analysis on contribution of antiphospholipid antibodies (aPL), singly or in combination, to the development of avascular necrosis (AVN)

<table>
<thead>
<tr>
<th>aPL</th>
<th>AVN group No (%)</th>
<th>Matched controls*</th>
<th>Univariate</th>
<th>Multivariate</th>
<th>Unmatched controls†</th>
<th>Univariate</th>
<th>Multivariate</th>
</tr>
</thead>
<tbody>
<tr>
<td>aCL</td>
<td>2/11 (18)</td>
<td>3/22 (14)</td>
<td>1.24</td>
<td>0.82</td>
<td>1.40</td>
<td>0.38</td>
<td>2.28</td>
</tr>
<tr>
<td>IgG aCL</td>
<td>3/11 (27)</td>
<td>6/22 (27)</td>
<td>1.32</td>
<td>0.74</td>
<td>1.57</td>
<td>0.73</td>
<td>9/31 (29)</td>
</tr>
<tr>
<td>LAC</td>
<td>2/11 (18)</td>
<td>5/22 (23)</td>
<td>0.99</td>
<td>0.99</td>
<td>1.57</td>
<td>0.80</td>
<td>4/31 (13)</td>
</tr>
</tbody>
</table>

*Adjusted for cumulative steroid dose.
†Adjusted for cumulative steroid dose and age of SLE diagnosis.
aCL = anticardiolipin antibodies; LAC = lupus anticoagulant; RF = rheumatoid factor.
Table 4  English literature search 1960–98: case reports of avascular necrosis (AVN) in primary or secondary antiphospholipid syndrome (APS)

<table>
<thead>
<tr>
<th>Authors (reference)</th>
<th>Patients with SLE studied (n)</th>
<th>Prevalence of AVN (% (No))</th>
<th>Previous of APL in patients with AVN</th>
<th>Prevalence of APL in control group (% (No))</th>
<th>Association of APL with AVN</th>
<th>Concomitant corticosteroid use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nagasawa et al²⁴</td>
<td>111</td>
<td>22 (24/111)</td>
<td>LAC</td>
<td>5 (11/44)</td>
<td>−ve</td>
<td>+ve</td>
</tr>
<tr>
<td>Alarcon-Segovia et al²⁵</td>
<td>500</td>
<td>6 (28/500)</td>
<td>aCL</td>
<td>23 (10/44)</td>
<td>+ve (p&lt;0.05)</td>
<td>+ve</td>
</tr>
<tr>
<td>Asherson et al²⁶</td>
<td>800</td>
<td>5 (37/800)</td>
<td>LAC and aCL</td>
<td>NS</td>
<td>−ve</td>
<td>+ve</td>
</tr>
<tr>
<td>Migliaresi et al²⁷</td>
<td>69</td>
<td>10 (7/69)</td>
<td>aCL</td>
<td>39 (24/62)</td>
<td>−ve</td>
<td>+ve</td>
</tr>
<tr>
<td>Mok et al²⁸</td>
<td>320</td>
<td>12 (38/320)</td>
<td>LAC</td>
<td>12 (16/139)</td>
<td>+ve (p=0.02)</td>
<td>+ve</td>
</tr>
</tbody>
</table>

aCL = anticardiolipin antibodies; LAC = lupus anticoagulant; SLE = systemic lupus erythematosus.

unmatched controls. Also displayed are the number of patients in the various groups with aCL and LAC. It can be seen that the number of patients with the antibodies and LAC is comparable in the various groups and indeed the overall frequency is relatively small. The formal analysis confirms that there is no evidence of any relation between these indicators and the presence of AVN. In addition, a test for the effect of having one or more of the two antibodies and LAC was not significant, with a significance level of 0.64 based on the matched controls and a significance level of 0.17 based on the unmatched controls.

Discussion

AVN is a well described complication of SLE. Dubois and Cozen were among the first authors to describe this condition in association with SLE in 1960.³ There have been many subsequent descriptions of AVN, but many reports that evaluated the proposed risk factors for its development in SLE failed to show consistent results supporting an association. Potential risk factors include corticosteroid use,₁⁻⁵ vasculitis,⁴⁻¹⁰ Raynaud’s phenomenon,⁴⁻⁶ and the presence of aPL. Our case-control study aimed at elucidating the role, if any, of the presence of aPL.

The point prevalence of AVN in our cohort is 4%, at the lower end of the reported incidence, which has ranged from 4 to 9%.¹¹ Our data, however, may be an underestimate as AVN was diagnosed in symptomatic patients only. It is interesting to note that patient 1 developed AVN in an isolated L2 vertebral body without evidence of disease elsewhere. This was an unusual presentation of AVN. Egan and Munn reported on another patient who presented with catastrophic APS and acute onset of AVN affecting multiple sites that included T8, L4, and L5 vertebral bodies.¹² Our patient 6 also had multiple sites affected. There have been a number of reports about AVN affecting as many as 13 sites in a lupus patient.¹³⁻¹⁴

Corticosteroids have long been regarded as a risk factor for the development of AVN. The histology of AVN is characterised by subchondral bone necrosis that occurs as a result of ischaemic injury. The vascular compromise could be attributed to a steroid induced hypercoagulative state,¹⁵⁻¹⁶ abnormal lipid metabolism as a result of corticosteroid use, or fat embolism.¹⁷⁻¹⁸ Moreover, hyper trophy of fat cells¹⁵⁻¹⁶ has been postulated to result in an increase in intraosseous pressure, which has been shown to compromise the arterial supply to the bone further.¹⁹

Corticosteroid use was invariably found in patients with SLE who developed AVN, with a few exceptions. In a meta–analysis of 22 papers, a strong correlation between oral steroid dose and incidence of AVN was found, whereas the bolus dose was not associated with AVN.²⁰ On the other hand, De Graaf et al found that the total amount of prednisone given during the first months after transplantation was critical for the development of AVN.²¹ This issue had been evaluated by Migliaresi et al, who found no difference in the highest corticosteroid intake for a single month, for 3, 6, and 12 consecutive months and the total corticosteroid intake between lupus patients with AVN and those without.²² In our study all patients with AVN had been treated with corticosteroids. Although not the primary focus of our study, we found no difference in the cumulative corticosteroid use between patients with AVN and unmatched controls.

Table 5  English literature search 1960–98: case reports of avascular necrosis (AVN) in primary or secondary antiphospholipoid syndrome (APS)

<table>
<thead>
<tr>
<th>Authors (reference)</th>
<th>1/ or 2/ APS</th>
<th>Age</th>
<th>Sex</th>
<th>Race</th>
<th>Site(s) of osteonecrosis</th>
<th>Previous corticosteroid use</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aljotas et al²⁶</td>
<td>1/</td>
<td>32</td>
<td>F</td>
<td>W</td>
<td>Lunate</td>
<td>−ve</td>
<td></td>
</tr>
<tr>
<td>Vela et al²⁷</td>
<td>1/</td>
<td>32</td>
<td>F</td>
<td>W</td>
<td>Left femoral head</td>
<td>−ve</td>
<td></td>
</tr>
<tr>
<td>Seleznick et al²⁸</td>
<td>1/</td>
<td>47</td>
<td>F</td>
<td>AC</td>
<td>Left femoral head, right knee</td>
<td>−ve</td>
<td></td>
</tr>
<tr>
<td>Egan et al²⁹</td>
<td>1/</td>
<td>25</td>
<td>F</td>
<td>W</td>
<td>Proximal femur, T8, L4, L5 vertebrae, manubrium, lower sternum, shoulders, elbows, wrists, ankles, tibia</td>
<td>−ve</td>
<td>1 month after hysterectomy for carcinoma of uterus, concomitant AIHA, leg ulcer, and RTA (IV)</td>
</tr>
</tbody>
</table>

₁/ = primary; ²/ = secondary; AC = Afro-Caribbean; AIHA = autoimmune haemolytic anaemia; DVT = deep vein thrombosis; F = female; RTA = renal tubular acidosis; W = white.
It is difficult to determine whether corticosteroid treatment itself, or the severity of underlying lupus, is directly implicated in the development of AVN as most patients with active disease are treated with corticosteroids. Vasculitis or other factors may account for the very few reports of patients with SLE with AVN who had not received corticosteroids.  

The data in our study, like that reported by Nagasawa et al., showed that a relatively small daily dose of corticosteroid was being used (5.4 mg) and that clinical disease was relatively inactive when AVN was diagnosed. Raynaud’s phenomenon, which has been proposed to be associated with AVN in some reports but not others, was present in three of our patients with AVN and six matched patients, with no difference demonstrable (p=0.99).

Whether aPL are present as “bystanders” in lupus patients with AVN or whether they are directly responsible for this condition remains controversial. Their prothrombotic potential suggests that aPL might predispose to AVN by causing microvascular thrombosis. In fact, thrombosis of terminal arteries in subchondral bone was identified in histological findings in non-traumatic AVN in one study but not in another. Table 4 shows the various authors reporting an association between aPL and the development of AVN.

The reported prevalence of aPL among patients with SLE with AVN ranged from 8 to 73%, depending on which aPL were measured. Some groups found an association when compared with lupus patients without AVN complications, but some did not. This discrepancy may be accounted for by the concomitant use of corticosteroids in these patients. None of these patients with positive aPL had clinical features of secondary APS.

There are a number of reports on patients with primary APS who had not corticosteroid treatment before and had AVN complications (table 5). These cases may be accounted for by the concomitant use of corticosteroids before and had AVN. None of these patients with positive aPL were measured. Some groups found an association between aPL and the development of AVN.

In summary, our data using carefully matched groups to permit us to allow for a variety of patient factors have failed to reveal a role for aPL in the development of AVN in patients with SLE. Other, as yet unidentified factors, or a combination of factors, may cause this significant damaging effect in these patients.

15 Congriff WW. Thromboembolic complications associated with ACTH and cortisone therapy. JAMA 1951;147:924–6.
Avascular necrosis of bone in patients with systemic lupus erythematosus


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