Malaria and lupus anticoagulant: a case study and review

Catherine Ronayne

Abstract
A young woman with a history of Plasmodium falciparum and schistosomiasis presented with anaemia and thrombocytopenia. A diagnosis of Plasmodium ovale malaria was made. Shortly after initiating treatment her anaemia worsened and she developed a circulating lupus anticoagulant, but had no clinical features of antiphospholipid syndrome. Potential mechanisms and interactions relating to her symptoms and laboratory results are explored.

Key words: Malaria, Plasmodium ovale, lupus anticoagulant, coagulopathy, systemic lupus erythematosus (SLE)

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Introduction
Malaria is associated with haemolytic anaemia, thrombocytopenia and coagulopathy, but these are most commonly found in Plasmodium falciparum and to a lesser extent, P. vivax infections (1-5). Immune-mediated mechanisms and consumption are proposed as the main causes of thrombocytopenia and coagulopathy, although myelosuppression, platelet dysfunction and sequestration also play a role (1,5,6). Thrombocytopenia and haemolytic anaemia may be exacerbated by some drug treatments (7-9). The purpose of this case study was to investigate the possible causes of thrombocytopenia, haemolytic anaemia and lupus anticoagulant in a patient with P. ovale malaria.

Case report
A 22 year old woman presented at the emergency department in Dunedin Hospital with tachycardia and recurrent febrile episodes, which occurred almost every second day, associated with abdominal pain. She had decreased oral intake and was passing dark urine. Blood samples were collected for full blood count (FBC), liver function tests (LFT) and coagulation studies.

Three months previously the patient had been treated for schistosomiasis and malaria in Tauranga Hospital following prolonged travel in Central and West Africa. P. falciparum had been diagnosed but a mixed infection was deemed a possibility. Laboratory staff in Tauranga kindly provided information, results and images about the case which are shown in Table 1 and Figures 1, 2, and 3. Medical staff in Dunedin considered that a treatment regimen for P. falciparum may not suffice for concurrent P. ovale infection, so also requested a malaria screen. The significant results from day 1 are shown in Table 2.

Table 1. Results from 3 months prior (Tauranga Hospital).

<table>
<thead>
<tr>
<th>Significant results</th>
<th>3 months prior</th>
<th>Reference interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Haemoglobin (g/L)</td>
<td>106</td>
<td>115 – 155</td>
</tr>
<tr>
<td>Platelets x10^9/L</td>
<td>60</td>
<td>150 – 400</td>
</tr>
<tr>
<td>Total bilirubin (μmol/L)</td>
<td>27</td>
<td>&lt; 20</td>
</tr>
<tr>
<td>C-reactive protein (mg/L)</td>
<td>50</td>
<td>&lt; 8</td>
</tr>
<tr>
<td>Blood film examination</td>
<td>P. falciparum with possible mixed infection. Parasite density 3%</td>
<td></td>
</tr>
<tr>
<td>Thick film examination</td>
<td>Positive</td>
<td>Negative</td>
</tr>
</tbody>
</table>

Results from 3 months prior (Tauranga Hospital).

Table 2. Results day 1.

<table>
<thead>
<tr>
<th>Full blood count</th>
<th>Day 1</th>
<th>Reference interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Haemoglobin (g/L)</td>
<td>114</td>
<td>120 – 155</td>
</tr>
<tr>
<td>Platelets x10^9/L</td>
<td>37</td>
<td>150 – 430</td>
</tr>
<tr>
<td>Blood film examination</td>
<td>P. ovale with possible mixed infection with P. malariae. Density 0.3%</td>
<td></td>
</tr>
<tr>
<td>Thick film examination</td>
<td>Positive</td>
<td>Negative</td>
</tr>
<tr>
<td>Malaria antigen test: P. falciparum</td>
<td>Negative</td>
<td>Negative</td>
</tr>
<tr>
<td>Pan Plasmodium (vivax, malariae, ovale)</td>
<td>Positive</td>
<td>Negative</td>
</tr>
</tbody>
</table>

Liver function tests

<table>
<thead>
<tr>
<th>Total protein (g/L)</th>
<th>61</th>
<th>60 – 80</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total bilirubin (μmol/L)</td>
<td>26</td>
<td>2 – 21</td>
</tr>
<tr>
<td>C-Reactive protein (mg/L)</td>
<td>63</td>
<td>&lt; 5</td>
</tr>
</tbody>
</table>

Initial investigations found mild normocytic normochromic anaemia and marked thrombocytopenia. Giemsa stained thin blood films (Sysmex SP-1000i; Sysmex, Kobe, Japan; Roche, Basel, Switzerland) revealed enlarged oval and fimbriated red cells with trophozoite and schizont forms of malarial parasites (Figures 4 and 5). Infected cells contained variable amounts of Schuffner’s dots and a single chromatin dot. The appearances were consistent with P. ovale, with a possible mixed infection with P. malariae. Parasite density was determined to be 0.3%. The diagnosis was confirmed by thick film examination (Figure 6) by two scientists and Plasmodium antigen serology by immunochromatographic assay (BinaxNOW Malaria, Alere Ltd, Waltham, Mas. USA). The falciparum antigen screen test was negative, while the pan plasmodium antigen test, which includes vivax, malariae and ovale, was positive.

Serum chemistry indicated a mild degree of hepatic impairment with slightly elevated total bilirubin, while an elevated C-reactive protein (CRP) suggested an inflammatory process. The activated partial thromboplastin time (APTT) was mildly prolonged. This was initially assumed to be attributable to liver impairment secondary to malarial infection, although liver enzymes were normal. A urine dipstick test was positive for haemoglobin.

It was decided that the patient probably had had a mixed infection with P. falciparum and P. ovale with the latter entering a liver phase. The patient was admitted to a ward and treatment was commenced with quinine and doxycycline, together with primaquine in attempt to eradicate the organism from the liver. Urine and faeces were tested for schistosomes but no parasite eggs were detected.
Laboratory testing was performed over the course of the patient’s stay in hospital (Table 3). The next day (day 2) her FBC results were similar, but total protein, bilirubin, CRP and APTT had all increased. Heparin contamination of the citrated plasma sample was excluded by a normal thrombin clotting time (TCT).

By day three, the parasite density had halved but the APTT was still prolonged despite normal liver enzyme levels. Mixing studies were performed, with analysis of a one to one mixture of patient and normal pooled plasma. This yielded a partial correction, suggesting the presence of an inhibitor such as lupus anticoagulant.

The following day (day 4), only two malarial parasites were seen on the entire blood film. The APTT was lower than previously, but still exceeded the reference interval. Total protein, bilirubin and CRP had all improved. While the platelet count also seemed to be recovering, there was a normocytic normochromic anaemia with haemoglobin falling to 94 g/L. Together with a markedly elevated lactate dehydrogenase (LDH) and reduced haptoglobin, this was consistent with haemolytic anaemia. Reticulocyte count was normal.

Lupus anticoagulant testing was performed on the citrated plasma samples from day 4 using Vitaclot (Vital Diagnostics, Bella Vista, NSW Australia). Testing involved kaolin clotting time (KCT) and dilute Russell’s viper venom time (DRVVT). Results were used to calculate the delta-KCT (DKCT) and the index of circulating anticoagulant (ICA). The results were compatible with the presence of lupus anticoagulant. Suggest repeat the test after 12 weeks to confirm the diagnosis.

Anticardiolipin antibody testing was performed using IgG ELISA kits (ImmunoConcepts Sacramento, CA) and was found to be negative. Results are shown in Table 4. A comment was added to the report suggesting repeating the test after 12 weeks to confirm the diagnosis.

The patient’s condition improved over days 5 and 6, with total bilirubin and haptoglobin returning to normal levels. Haemoglobin reached a nadir on day 5, recovering on day 6, along with the platelet count. No malarial parasites could be seen on blood film examination. She was discharged on day 6 with instructions to continue taking quinine and doxycycline for seven days, and primaquine for eight weeks.

### Discussion

This patient had a complicated presentation and history with prolonged malaria, schistosomes, drug treatment, haemolytic anaemia, thrombocytopenia and lupus anticoagulant. Potential causes and relationships between these features are discussed below.

### Anaemia

**Malaria associated anaemia**

Dyserythropoiesis, ineffective erythropoiesis, inflammation, splenic pooling and haemolysis have all been implicated in normocytic anaemia associated with malarial infection (4,5,9). In this case study the patient presented with mild anaemia and dark urine containing haemoglobin which can be attributed to haemolysis from the malarial infection.

Extravascular haemolysis predominates, as parasitized red cells are pitted by macrophages in the spleen, resulting in reduced membrane deformability and increased fragility. Non-parasitized red cells may also be destroyed by hyperactive splenic macrophages and altered membranes due to immune and non-immune mechanisms. Intravascular haemolysis is more common in severe infection, particularly with *P. Falciparum* (5).

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**Table 3. Results during admission.**

<table>
<thead>
<tr>
<th>Full blood count</th>
<th>Day 2</th>
<th>Day 3</th>
<th>Day 4</th>
<th>Day 5</th>
<th>Day 6</th>
<th>Reference interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Haemoglobin (g/L)</td>
<td>111</td>
<td>101</td>
<td>94</td>
<td>84</td>
<td>87</td>
<td>120 – 155</td>
</tr>
<tr>
<td>Platelets (x10^9/L)</td>
<td>32</td>
<td>38</td>
<td>54</td>
<td>91</td>
<td>140</td>
<td>150 – 400</td>
</tr>
<tr>
<td>Reticulocytes (x10^9/L)</td>
<td>-</td>
<td>19</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>20 – 90</td>
</tr>
</tbody>
</table>

| Coagulation studies       |       |       |       |       |       |                  |
| Prothrombin time (s)      | 16    | 13.6  | 13    | -     | -     | 9-14             |
| Activated partial thromboplastin time (s) | 48    | 40    | 36    | -     | -     | 22 – 34          |
| Thrombin clotting time (s) | 14.3  | -     | 16.1  | -     | -     | < 20.0           |

| Liver function tests      |       |       |       |       |       |                  |
| Total Protein (g/L)       | 52    | 55    | 57    | 53    | 58    | 60–80            |
| Total Bilirubin (μmol/L)  | 30    | 24    | 21    | 13    | 9     | 2–21             |
| C-reactive Protein (mg/L) | 100   | 102   | 55    | -     | 14    | <5               |
| LDH (U/L)                 | -     | 758   | 857   | 745   | 655   | 85–285           |
| Haptoglobin (g/L)         | -     | <0.05 | -     | <0.05 | 0.05  | 0.3–2.7          |

| Table 4. Lupus anticoagulant and anticardiolipin antibody test results. |
|---------------------------|------------|------------|
| Lupus anticoagulant testing | Day 4 | Reference interval |
| Prothrombin time (s)      | 13        | 9 – 14     |
| Activated partial thromboplastin time (s) | 36    | 22 – 34    |
| Thrombin clotting time (s) | 16.1     | < 20.0     |
| Kaolin clotting time (s)  | 107       | 59 – 100   |
| Delta-KCT                 | 0.53      | 0 – 0.10   |

| Index of circulating anticoagulant | 0.39 | < 0.16 |
| Dilute Russell’s viper venom time (s) | 33   | 30 – 48 |

**These results are compatible with the presence of lupus anticoagulant. Suggest repeat the test after 12 weeks to confirm the diagnosis.**

**Anticardiolipin antibodies**

Cardiolipin IgG (GPL units) | 19 | <20 |
Anaemia may be exacerbated by bone marrow suppression, with evidence of malaria-associated dyserythropoiesis, premature erythroblast and stem cell death, and impaired haem synthesis. Tumour necrosis factor-alpha (TNF-α) has been implicated in animal studies of malaria associated ineffective erythropoiesis, but other than its role in anaemia of chronic inflammation, the exact mechanism is unclear (4.5).

Interestingly, anaemia tends to be worse with *P. falciparum* infection than with other plasmodia species. This is thought to be due to increased parasitaemia as it infects all red cells populations, while *P. ovale* and *P. vivax* tend to infect reticulocytes, and older cells are selected by *P. Malariae* (4).

**Drug-induced haemolytic anaemia**

Our patient’s anaemia worsened once treatment began, with moderately elevated LDH and undetectable haptoglobin by day 2. This is suggestive of drug-induced haemolysis, particularly if she had previously been exposed to the causative agent (10). Two of the drugs she was prescribed, quinine and primaquine, are associated with haemolysis in people with glucose-6-phosphate dehydrogenase (G6PD) deficiency.

Quinine is derived from the bark of the cinchona tree and its antimalarial properties have been recognised since the 17th century. Although the development of chloroquine-resistant malaria, quinine has had somewhat of a resurgence. The mode of action is unclear, but is thought to involve elevations in intracellular pH. It is used to treat other conditions, including lupus and arthritis, but is no longer recommended for treating muscle cramps due to the risk of thrombocytopenia (11). Quinine-induced haemolytic anaemia has been reported in patients with G6PD deficiency, and cardiac arrhythmia in patients who are elderly or have pre-existing cardiovascular disease. Interestingly, the cinchona alkaloids in quinine are a potent stimulator of insulin secretion, so glucose should be monitored, particularly in pregnant women (9).

Hypofibrinogenemia, an alteration in pharmacokinetics of anticoagulants, neutropenia, thrombocytopenia and renal failure have also been associated with quinine therapy (12).

Primaquine is used to prevent relapse of malaria but its exact mode of action is unknown as none of its metabolites have been definitively identified as anti-malarial (7). It is interesting to note that of the five plasmodia species known to infect humans (*P. falciparum, P. knowlesi*, *P. malariae, P. ovale* and *P. vivax*), only *P. ovale* and *P. vivax* develop dormant forms in the liver, enabling replases ranging from 16 days to several years after the original infection (7). However, there is some debate about this, as relapses have been reported with both *P. falciparum* and *P. malariae* despite liver hypnozoites not being found (13,14).

Primaquine was developed to prevent malarial relapse in soldiers and was first used by American troops during the Korean War. It is associated with mild methaemoglobinemia of little clinical significance, and acute haemolysis in people with G6PD deficiency. The reason for this is unclear, as primaquine appears to activate of the hexose-monophosphate shunt independently of glutathione. The severity of haemolysis varies unpredictably between different G6PD variants with some developing life-threatening crises, while others only have mild, self-limited haemolysis even with continuous therapy (7).

G6PD screening was negative in our patient, but haemolysis subsided once the primaquine dosage was reduced. Perhaps this is coincidental or due to an unknown mechanism independent of G6PD.

**Thrombocytopenia**

**Malaria and thrombocytopenia**

Thrombocytopenia is a common finding in malaria, particularly in *P. falciparum* and *P. vivax* infections where it has been noted in 60-80% of cases (2,5,6). Malaria should always be considered in the differential diagnosis for a febrile patient with thrombocytopenia but its value as a prognostic indicator varies between causative species. While one study found that a platelet count of less than 150x10^9/L was highly sensitive for malarial diagnosis (2), another suggests that the severity of infection is independent of the degree of thrombocytopenia (15). Clinical bleeding is rare, occurring in less than 5-10% of patients with severe disease (3). This may be due to enhanced haemostatic responses caused by hyperactive platelets (4,5).

The exact mechanisms of thrombocytopenia are uncertain. With severe infection, it may be caused by disseminated intravascular coagulation (DIC), but this does not occur in the vast majority of patients, including ours (4,6). Other proposed causes include peripheral destruction and consumption, immune-mediated lysis, splenic sequestration, dysmegakaryopoiesis and drug related effects (2,3,5,6).

Malarial proteins may act as B-cell mitogens, triggering antiplatelet antibodies late in the course of infection, causing an autoimmune thrombocytopenia (1,5,6). Given the protracted history of our patient, this may have been a factor. Elevated titres of platelet associated IgG have been demonstrated in thrombocytopenic patients with *P. falciparum*, and these decrease as the platelet count recovers (6). Some platelets may become activated and injured in this process, losing membrane sialic acid, resulting in intravascular lysis (3,5).

Immune complexes consisting of malarial antigen and antibodies attach to platelets, causing sequestration and destruction in the spleen (5,6). Hyperactive splenic macrophages, interleukin-1 and TNF may also play a role in platelet destruction, irrespective of antibodies (5). Bone marrow megakaryocytes may be normal or increased during infection, but platelet destruction is increased, with significantly elevated thrombopoietin levels in patients with severe infection (3-5).

**Drug-induced thrombocytopenia**

Given our patient presented with thrombocytopenia and it improved over the course of treatment, drug-induced thrombocytopenia is unlikely. It has been reported with both quinine and doxycycline, with published accounts of quinine-related purpura as early as 1865 (16). Drug-dependent IgG class antibodies to platelet glycoproteins GPIIb/IIa and GP1b/IX react with platelets in the presence of soluble quinine at pharmacologic concentrations and higher (8,12). There are no reports in the recent literature of quinine-induced thrombocytopenia occurring during treatment of malaria (3). Perhaps this is due to the shorter timeframe of drug exposure with current treatment guidelines.

**Coagulopathy and lupus anticoagulant**

It is difficult to assess the significance of coagulopathies in malaria due to concurrent and associated complications such as haemolysis, liver and renal dysfunction and the effect of drug treatments (3). Coagulation pathways are often activated by malaria, but spontaneous bleeding and DIC are uncommon, even in severe infection (9).

Platelet dysfunction is common but was neither suspected nor investigated in this patient. If it was occurring, it was unlikely to contribute to the apparent coagulopathy. Platelet hyperactivity which may occur initially in acute infection would potentially lead to coagulation activation and a reduced APTT, while hypoactivity which may occur later, should have no effect on APTT (4,5).

Lupus anticoagulants encompass a spectrum of antibodies against phospholipids and associated protein epitopes, including prothrombin, protein C and S. They are often concurrent with anticardiolipin antibodies and both cause antiphospholipid syndrome (APS). Lupus antibodies may be associated with systemic lupus erythematosus (SLE) and other connective tissue disorders, malignancy, infection, drugs or they may be idiopathic and transient. The term ‘anticoagulant’ is
a misnomer. In vitro they inhibit coagulation tests that require phospholipid, most notably the APTT. The prolonged APTT does not correct, or only partially corrects when mixed 1:1 with normal plasma. However, in vivo lupus anticoagulants are hypercoagulable and cause arterial and venous thrombosis, recurrent miscarriage, and focal cerebral and ocular ischaemia.

Coagulation testing suggests our patient developed lupus anticoagulant but she had no clinical features of APS. There are several possibilities: it is a genuine lupus antibody that has been induced by the malarial infection or a drug; it was pre-existing but silent and has been exacerbated by the infection or a drug; or it is a false positive.

Malaria and lupus anticoagulant
There are countless documented cases of coagulopathy due to *P. falciparum* but little literature regarding an association with lupus anticoagulant, or other types of malarial infection, including *P. ovale*. Interestingly, there is evidence of immune-mediated resistance against *P. falciparum* associated with SLE, but none of these studies mention if the test subjects had concurrent circulating lupus anticoagulant (17-20).

Schistosomes and lupus anticoagulant
Our patient had a history of schistosomiasis as well as malaria. Could schistosomes induce lupus anticoagulant? There are reports of immune disturbances associated with chronic schistosomal infection. A study in the Philippines found that chronic infection with *Schistosoma japonica* in pregnancy creates a pro-inflammatory state, causing maternal, placental and fetal inflammation and reduced birth weight. However, multiple species of nematode were present which could also contribute to the inflammation (21).

Another study identified elevated titres of antinuclear antibodies in the sera of mice acutely infected with *Schistosoma mansoni*, five to six weeks after the onset of infection (22). Both of these studies suggest that cross-reactivity between parasites and self-antigens could trigger autoimmune disease, but neither tested for anticardiolipin or lupus antibodies.

Drug-induced lupus anticoagulant
A wide variety of drugs have been found to cause asymptomatic autoimmunity, lupus-like illnesses and SLE. The most frequently implicated are procainamide (antiarrhythmic), hydralazine (antihypertensive), isoniazid (anti-tuberculosis) and phenytoin (anticonvulsant). The causative mechanisms are unclear. Some of these drugs act by disrupting cell membranes, which could theoretically result in altered antigens or antigen density on the cell surface. Drug-induced antibodies (similar to mechanisms proposed in immune thrombocytopaenia and anaemia) may also play a role (23).

Could any of the drugs our patient was prescribed have caused drug-induced lupus? There are no reports of primaquine-induced lupus, but guidelines suggest its use is contraindicated in patients with SLE due to a risk of neutropenia (24).

Doxycycline (vibramycin) is a tetracycline antibiotic used to treat a wide variety of conditions including Lyme disease, acne and anthrax. It can be used for malarial prophylaxis or with other drugs (such as quinine) to treat malaria infection. While there are no reports of doxycycline causing lupus, a similar tetracycline antibiotic, minocycline, has been implicated. A 43 year old woman was prescribed minocycline for acne vulgaris. After 10 days of treatment she developed polyarthritis and pyrexia, with elevated liver enzymes and antinuclear antibodies (1:640 homogeneous). Symptoms resolved on discontinuation of the drug, and laboratory tests returned to normal after 8 weeks. Lupus anticoagulant testing was not performed (25).

There are a few reports of lupus-like syndromes occurring with quinine therapy. An Australian study described 31 elderly patients with circulating lupus anticoagulant identified during routine testing. Of these, 10 were on quinine for night cramps, 11 were on quinidine (a stereoisomer of quinine) for arrhythmia, and 2 patients were on both. The minimum duration of treatment was 6 months for quinine and 2 years for quinidine. Five patients had thrombosis or other features of antiphospholipid syndrome. The offending drug was stopped in 5 patients but when retested, the lupus anticoagulant persisted in two of them up to 20 months after initial presentation (26).

Another case describes quinine-induced autoimmunity in a patient with malaria. A 30 year old woman was diagnosed with *P. falciparum* infection and treated with 600 mg of quinine sulphate, three times a day. After 6 days she developed a pericardial effusion. Lupus anticoagulant testing was negative but anticardiolipin and antinuclear antibodies were positive (1:800 speckled). Symptoms abated within 48 hours of quinine withdrawal and her antibodies returned to normal after 2 weeks (27).

Drug-induced lupus has been reported in malarial prophylaxis. A 33 year old man took a single tablet of Fansidar (sulfadoxine and pyrimethamine) and chloroquine in preparation for a trip to Pakistan. Six days later he developed an erythematous rash, conjunctivitis, mouth ulcers and widespread petechiae. A diagnosis of Stevens-Johnson syndrome with circulating lupus antibodies was made. He was treated with steroids, antihistamines and IV fluids, and returned to normal within 3 days (28). Fansidar is no longer recommended as prophylaxis because of increasing resistance and the risk of adverse reactions (9,29).

False positive lupus anticoagulant
Our patient met the criteria for lupus testing with an unexplained prolonged APTT, but in such a complex case, we should not exclude the possibility of a false result. The coagulation testing methods used are more liable to produce false negatives due to sample problems. Our samples were collected and prepared according to current guidelines to minimise contamination with platelets, haemolysis and jaundice (30).

False positives are fairly common due to the variability of antibodies and poor specificity of some assays. While no single test is sensitive for all lupus anticoagulants, the latest guidelines from the International Society on Thrombosis and Haemostasis recommended the DRVVT and sensitive silica based APTT, rather than the KCT. Kaolin is no longer recommended as an activator due to poor reproducibility and problems in some automated coagulometers (30).

As the DRVVT was negative in our patient, did she really have lupus anticoagulant? Tests for anticardiolipin antibodies were also negative and phospholipid dependence was not proven. Both warfarin and clexane may cause false positives, but our patient was on neither of these drugs. The effect of her prescribed treatments on lupus testing is unknown, and perhaps warrants further investigation if other cases are reported. It is possible that her infection caused elevated levels of acute phase reactants (e.g. FVIII) which may interfere with testing. Confirmatory testing should be performed at least 12 weeks after an initial positive result (30). At the time of writing, this had not been done.

Limitations
Unfortunately, limitations to this case study are many. We have no previous history, tests or samples on this patient, so we cannot exclude a pre-existing but silent lupus antibody. To date, no follow-up testing has been done, making it difficult to draw conclusions. It may well be that the antibody has disappeared with the removal of infection and drug stimuli. However, drug-induced antibodies may persist in the absence of the drug and transient antibodies may be reactivated with another immunological challenge. This may be of important clinical significance in the future.
This case illustrates the complexity of haematological changes associated with malarial infection. In particular, the effects on coagulopathy and autoimmunity are poorly understood. The significance for our patient is uncertain, given that circulating lupus anticoagulants may persist for months or years, even after clearance of the precipitating infection or drug. As more people travel to malarial endemic areas, it will be interesting to see if any similar cases emerge.

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Dr Gerard de Jong, Consultant Physician, Department of Internal Medicine, Dunedin Hospital, Southern DHB; Murray Smith, Murray Robinson and staff at Pathlab Bay of Plenty for images and results from Tauranga; Professor Ian Morison, Department of Pathology, Dunedin School of Medicine and Rhonda Lucas, Haematology Laboratory, SCL Dunedin Hospital for proof-reading and suggestions. This case was presented at the NZIMLS Haematology Special Interest Group Meeting, Nelson, February 2012.

Conclusion

Acknowledgements

Dr Gerard de Jong, Consultant Physician, Department of Internal Medicine, Dunedin Hospital, Southern DHB; Murray Smith, Murray Robinson and staff at Pathlab Bay of Plenty for images and results from Tauranga; Professor Ian Morison, Department of Pathology, Dunedin School of Medicine and Rhonda Lucas, Haematology Laboratory, SCL Dunedin Hospital for proof-reading and suggestions. This case was presented at the NZIMLS Haematology Special Interest Group Meeting, Nelson, February 2012.

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References

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