decisions the court held that a vendor who negligently supplied a minor with alcohol, which causes intoxication or impairment of the minor's driving ability, is liable to third persons in the proportion that the negligence in selling the alcohol was a substantial factor in causing the injuries. In England and Wales such liability could exist only either at common law or framed as a breach of statutory duty if the retailer knew or ought to have known that the purchaser was intending to or was likely to drive a motor vehicle and that he was intending to or was likely to drink before (rather than after) driving sufficient alcohol to impair his driving substantially. The fact that the purchaser was under age for the purchase of alcohol would be a factor for consideration but would not of itself give rise to liability.

It may well be that actions along these lines will be taken in the future. In Britain there is not such a great incentive to search for additional defendants having regard to the more comprehensive insurance cover required of motorists here and having regard to the back stop cover provided by the Motor Insurer's Bureau in the

case of uninsured motorists. But as the costs of motor insurance increase the insurers themselves may seek contributions from people other than motorists directly concerned. In the long run this may tend only to spread the load on to other insurance risks, such as the third party risk cover usually included in a householder's policy. Eventually, teetotallers may get special rates on their householder's policies, just as smokers ought to already. On the other hand, and more desirably, a change in social customs might be achieved.

References

- 1 Attorney General's Reference No 1 of 1975 [1975] QB773.
- 2 Accessories and Abettors Act, 1861, section 8.
- 3 *R v Bainbridge* [1960] 1 QB 129.
- 4 *Donoghue v Stevenson* [1932] AC 567, 579 per Lord Atkin.
- 5 *Adderley v Great Northern Railway Company* [1905] 2 1. R. 378.
- 6 *Jordan House v Menow and Housberger* (1973) 38DLR 3d 105.
- 7 *Kelly v Gwinnell*, June 27, 1984, 476 A.2d 1219.
- 8 *Sorensen v Jarvis*, June 28, 1984, 350 NW 2d108.

Around Europe

Two cases of falciparum malaria acquired in Britain

DONALD WHITFIELD, C F CURTIS, G B WHITE, G A T TARGETT, D C WARHURST, D J BRADLEY

Abstract

Two cases of severe falciparum malaria contracted in the United Kingdom occurred in residents of Sussex, living 10 and 15 km from Gatwick airport. One patient was the landlord of a public house much frequented by aircrew, and the other was the wife of a worker at the airport, who travelled close to the public house on the probable date she contracted her infection. Transmission was most probably due to the bite of an infected imported tropical anopheline mosquito transported in a vehicle from the aircraft to the site of transmission during the very hot and humid weather of July 1983.

Prevention of further cases depends on increased diligence in "blocks-away" destruction of insects in aircraft flying from endemic areas, but there is a need for more study of acceptable alternative ways of delivering the insecticide. This "airport

malaria" is well recognised on the continent, and physicians should be aware of its existence in those who have not travelled abroad but live or work near international airports.

Introduction

Malaria infections are often contracted in the tropics, with the disease developing after the patient has come to a temperate country. Between one and two thousand such cases have been seen in Britain annually in recent years.¹ Transmission of malaria within England has occurred in the past, but the last reported case of indigenous malaria in Great Britain was in 1953.²

Nevertheless, two patients with proved falciparum malaria were admitted to Crawley Hospital, Sussex, in August 1983 having contracted the disease in Britain. This paper describes the clinical and epidemiological aspects of these two patients and discusses the entomological investigations made to determine the likely source of infection. A fuller account of the entomological basis is available elsewhere.³

The patients

CASE 1

On 2 August 1983 a 48 year old publican was admitted semicomatose and delirious to the isolation ward of Crawley Hospital. The history was obtained partly from his general practitioner's referral letter and partly from his wife. A fortnight previously he had felt nauseated, lost his appetite, and developed a severe headache. The next day he had felt worse, developed a fever associated with sweating and rigors, and also had bouts of vomiting and diarrhoea. Two days after the onset of his illness he called in his general

Crawley Hospital, Crawley, Sussex RH11 7DH

DONALD WHITFIELD, MA, FRCP, consultant physician

Division of Communicable and Tropical Diseases, London School of Hygiene and Tropical Medicine, London WC1E 7HT

C F CURTIS, BA, PHD, Medical Research Council external staff senior lecturer in entomology

G B WHITE, PHD, ARCS, senior lecturer in entomology

G A T TARGETT, PHD, DSC, professor of immunology of protozoal diseases

D C WARHURST, PHD, MRCPATH, senior lecturer in medical protozoology, and microbiologist, Public Health Laboratory Service Malaria Reference Laboratory

D J BRADLEY, DM, FRCPATH, professor of tropical hygiene, codirector of Public Health Laboratory Service Malaria Reference Laboratory

Correspondence to: Dr C F Curtis.

practitioner, who found that he had a temperature of 38.5°C but could find no localising signs. He was treated with erythromycin. Two days later he felt very much better but still weak. Two days after this he once again developed a severe headache, sweated profusely, and had violent rigors; he also began to hiccup. The erythromycin was continued and once again after three days he felt better and could take food without vomiting.

After a further two days he felt hot and cold and became delirious. The diarrhoea returned and for the rest of the week he became progressively worse and could tolerate only fluids.

There was nothing important in the history, and his only medication had been erythromycin, aspirin for his headache, and nitrazepam for two nights. There was a history of fairly heavy drinking and he smoked 20 cigarettes a day.

On examination his temperature was 39.8°C with a pulse rate of 120 and a blood pressure of 90/50 mm Hg. There was no sign of jaundice or cyanosis and no lymphadenopathy. He was not responsive to commands, his tongue was furred, and he had herpes labialis. The chest was clear and there were no abnormalities in the cardiovascular system. The liver edge was easily palpable 4 cm below the costal margin, but the spleen was not palpable. He had an erythematous rash on the lower abdomen. Despite the fact that he had not been abroad in the past two years, and then only to the south of France, the periodicity of his illness, the headache, and the delirium suggested the possibility that he might be suffering from cerebral malaria. The differential diagnosis seemed to lie between this and a toxic confusional state, cause unknown. Blood smears sent to the laboratory were immediately reported as showing a heavy infection with *Plasmodium falciparum*. Accordingly he was given quinine 10 mg/kg body weight in 500 ml dextrose saline intravenously and chloroquine 200 mg intravenously immediately, followed by routine oral dosage. The blood picture on admission showed a red cell count of $4.11 \times 10^{12}/l$, haemoglobin concentration 10.0 g/dl, and a white cell count of $4.4 \times 10^9/l$. His red cell count fell rapidly to $2.79 \times 10^{12}/l$ and his haemoglobin concentration to 9.8 g/dl. The bilirubin concentration rose to 46 $\mu\text{mol}/l$ (2.7 mg/100 ml) and the lactic dehydrogenase activity to 486 IU/l.

The quinine was continued every eight hours for 24 hours intravenously and he appeared to be recovering well except for a temporary setback on 4 August due to a condition unconnected with the malaria. On 5 August he was much better but his urinary output was poor and his blood urea concentration had risen to 18.7 mmol/l (112 mg/100 ml) compared with 17.7 mmol/l (106 mg/100 μl) on admission. On 5 August his spleen became palpable for the first time. After a full course of chloroquine he received 15 mg primaquine daily to eliminate gametocytes and avoid the possibility of infecting local mosquitoes. There was a dramatic fall in his blood urea concentration to 8.0 mmol/l (48 mg/100 ml). The results of other investigations, including blood cultures, were negative.

He was not transfused and on discharge on 12 August his haemoglobin concentration was 10.6 g/dl with a red cell count of $3.3 \times 10^{12}/l$ and normal platelets. He subsequently made a complete recovery and his blood picture returned to normal after a full course of ferrous sulphate. The confusing clinical response to erythromycin seen after the onset of the illness is of interest as this agent has mild antimalarial activity.^{3a}

CASE 2

This patient was admitted from Horsham on 18 August 1983, her general practitioner having found falciparum malaria parasites in her blood. She had been unwell for 10 days and felt as if she was getting influenza. She had had abdominal pain for five days and diarrhoea with pale stools and dark urine for three days. She had been abroad in Majorca for the last week in June 1983 and stayed in an hotel. The history was unremarkable. On admission she was jaundiced with a fever of 38.0°C and a pulse of 100, good volume and regular. Her blood pressure was 120/80 mm Hg. There were no abnormal signs in the heart, chest, or abdomen, but she had slight photophobia without neck stiffness or other signs in the central nervous system.

A repeat blood film confirmed the presence of falciparum malaria, with a haemoglobin concentration of 10.6 g/dl and red cell count of $3.51 \times 10^{12}/l$. The white cell count was $2.6 \times 10^6/l$. Her serum electrolyte concentrations were normal, but the bilirubin was 65 $\mu\text{mol}/l$ (3.8 mg/100 ml), with enzyme activities of alkaline phosphatase 154 IU/l, lactic dehydrogenase 560 IU/l, serum alanine transaminase 42 IU/l, and serum aspartate transaminase 63 IU/l.

She was immediately given oral chloroquine 600 mg initially, followed by 300 mg every six hours, to a total of 1.5 g. Her clinical condition improved dramatically and her temperature returned to normal on the third day. Nevertheless, her haemoglobin concentration fell to 7.7 g/dl and her red cell count to $2.5 \times 10^{12}/l$. Four units of blood were transfused, with an immediate effect on her blood picture, which returned to normal on 23 August. Her

spleen became palpable on 24 August for the first time but rapidly regressed in size, and on discharge, on 26 August, she felt perfectly well with no splenomegaly. She was discharged taking primaquine 15 mg daily for 10 days to eliminate gametocytes.

Cultures of blood for malaria parasites were set up from pretreatment blood, but the long delay between collection and culture (the blood was not collected with that aim in mind) meant that no parasites were viable. Had they grown, the isoenzyme patterns of the *Plasmodium* would have permitted comparison of strains infecting the two cases.

Epidemiology

These two patients had severe and unequivocal falciparum malaria, which was almost lethal in case 1. On the basis of their histories, the patient in case 1 became ill first on about 19 July 1983 and the patient in case 2 on about 8 August. Neither had been abroad to an area endemic for falciparum malaria. In case 1 the patient had not left the United Kingdom at all in the two years before becoming ill, and before that had visited only southern France. In case 2 the patient had visited Majorca six weeks before becoming unwell, but there is no malaria transmitted there, nor has there been for 22 years, and no introductions of infection there in 1983 have been reported. As flights from Majorca are direct and do not extend further to the tropics the possibility of infection of this patient on the aeroplane is particularly remote, and in any case six weeks is too long an incubation period in a non-immune person infected with *P. falciparum*.

Both patients must therefore have been infected in the United Kingdom. Neither had received a blood transfusion or blood products by injection within the previous year. It therefore appears that both were infected by the bite of infected anopheline mosquitoes and their possible origin needs to be considered. There are three main possibilities: they were infected by imported infected mosquitoes, or the mosquitoes were imported but became infected with malaria in Britain, or indigenous mosquitoes became infected from an imported case of falciparum malaria. The patients became infected probably 10-14 days before their first symptoms⁴ about 5-9 July in case 1 and 25-29 July in case 2. Both infections were acquired during the prolonged hot summer of 1983. Both patients lived near Gatwick airport and their homes were 5.5 km apart.

The patient in case 1 was the landlord of a public house located 10 km west of the airport buildings at Gatwick airport. He had not visited the airport recently. Nevertheless, in spite of its rather isolated location, his public house was frequently visited by aircrew from Gatwick, who comprise over 5% of his numerous customers. The patient in case 2 lived further from Gatwick airport, 13 km south west, in a suburban area of north west Horsham. The countryside of this whole area is well wooded. Her husband worked at Gatwick airport but was concerned with furnishings for the aeroplanes and did not work on those in service. His blood showed neither parasites nor antimalarial antibodies. His wife accompanied him on a short visit to the airport on 14 July but did not visit it thereafter. She also travelled on the evening of 29 July (about the day on which she became infected) between Horsham and Reigate by motor scooter, passing close to the residence of case 1. The weather was very hot and her arms and legs would have been exposed to mosquito bites, though she did not stop appreciably on the journey, except presumably for traffic at intersections. The incubation period of falciparum malaria has a range of eight to 25 days with for most cases 10-14 or 10-16 days.⁴ Possibly the two infections might have been contracted as little as three days apart if the range of incubation periods is used (as low as 14 days apart with a 10-16 day incubation period, and about 20 days apart on identical incubation periods for the two cases⁴). Both patients might have contracted malaria at almost the same site not less than 18 days apart. Moreover, it is difficult to disregard the proximity of Gatwick airport, as in spite of the long, hot summer no other indigenous cases of malaria were recorded in Britain, with the possible exception of two people who had travelled from London (Heathrow) airport to Rome on an aeroplane that had come from tropical areas before the patients boarded it.⁵

Possibility of transmission by indigenous mosquitoes

Two species of anopheline mosquitoes were found in the area. *Anopheles claviger* was found breeding near the houses of both patients, and a few larvae of *An plumbeus* were discovered in a tree hole near the house in case 1 as late as September 1983. *An claviger* rarely bites man and is probably not susceptible to *P falciparum* of African origin (unpublished observation of P G Shute quoted by Ramsdale and Coluzzi⁶), and there is no evidence to favour it as a potential vector. The situation regarding *An plumbeus* is less clear. It commonly bites man. There is no evidence that it is susceptible to tropical *P falciparum* (Shute's (1954)⁷ statement misquotes the literature), but none to the contrary either. Moreover, the unusually hot summer of 1983, with a mean monthly temperature just over 20°C, was adequate for completion of development of *P falciparum* in the mosquito in about 12 days.⁸ Nevertheless, the opportunity for an indigenous mosquito to become infected in the Gatwick area is very small: only five cases were notified from northern Sussex over the relevant two months and they were on average treated within nine days of symptoms arising, so were unlikely to have gametocytes infective to mosquitoes. And, though asymptomatic gametocytaemic visitors pass through Gatwick airport, the chance of their being bitten by an indigenous mosquito that then reached the two patients is even less likely than for an imported mosquito.

The second possibility, of an imported vector becoming infected within the UK, seems particularly unlikely in that the opportunities for a mosquito imported from tropical Africa to become infected before departure for the UK would be very much greater in the endemic area than in the UK. This second possibility combines the weakest links in both the other possible routes of transmission.

The third, and on balance most likely, possibility is of importation of an infected vector or vectors. Flights from the holoendemic areas of west Africa regularly arrive at Gatwick, and for various reasons not every aeroplane from there was being disinfected with an adequate quantity of insecticide. Searches of 67 aircraft subsequent to this malaria outbreak yielded occasional live, pyrethroid susceptible culicine mosquitoes of tropical origin, so that the possibility of importation exists, though no tropical anophelines were detected in these searches.^{3,9} Identification of the likely source of some of the *Culex* caught was possible by breeding from the females collected and examination of male genitalia of the offspring, indicating that Entebbe and Lagos respectively were the probable sources of the mosquitoes. Mosquitoes arriving on aircraft would be unlikely to fly unaided to the homes of the two cases and, assuming that they would have been blown out of the wheelbays during take off, there would be no chance of mosquitoes dispersing directly from the wheelbays when they opened on the approach to Gatwick. A more plausible means of transport would be in the car of the patient's husband to Horsham in case 2 and in the vehicles belonging to aircrew to the Rusper public house, which was used by many airport staff. It seems unlikely that two arriving infected mosquitoes should disperse in different vehicles (in the absence of other cases from mosquitoes staying at Gatwick) and we would suggest that the simplest explanation is of a single imported infected African *Anopheles* mosquito transported to the public house and biting both patients in the same area some time apart.

Discussion

In recent years at least 19 cases of so called "airport malaria" have been recorded¹⁰ from north western Europe, occurring usually during high summer in people living or working within five km of major international airports, as at Paris,¹¹ Zürich,¹² Amsterdam,¹³ and Brussels.¹³ These have been attributed to the importation of infected tropical mosquitoes. Before 1983 no such event had been described from the UK. The two present patients are unusual in living rather further from the airport than is typical but otherwise fit the pattern of airport malaria and clearly, especially in very warm weather, it is necessary to bear falciparum malaria in mind in the differential diagnosis of fever and coma in those who live in the vicinity of international airports receiving traffic from malarious

areas. Fortunately hospitals in such areas are likely to be aware of the risks of malaria as they also receive cases of malaria presenting on the incoming aircraft.

Two additional British cases from the summer of 1983 did not appear to have been infected in known malarious areas. They were reported from London¹⁵ and Durham¹⁶ independently but were subsequently found to have travelled on the same flight from London (Heathrow) to Rome and may have become infected en route by a mosquito infected in Africa which could have boarded the aeroplane in Ethiopia.⁵ It is now clear that the United Kingdom is not exempt from airport malaria. The methods of enzyme electrophoresis and other means of infraspecific taxonomy of both parasites and vectors, as used and attempted in these cases, may indicate the likely origin of the mosquitoes and the malaria, and efforts are needed to preserve both insects and parasites alive whenever the opportunity presents.

If it is accepted that these cases are due to imported infected vectors, the emphasis in control and prevention must fall on the killing of insects on aircraft (disinsection), which by international regulation should be carried out just before take off from the airport of departure in the tropics. The observations discussed fully by Curtis and White³ on survival of insects under various levels of insecticide application suggest that the problems concern implementation and that the dosages recommended by the World Health Organisation are adequate.¹⁷ There appear to be considerable difficulties both in assuring adequate supplies of insecticide and in using it without problems of passenger reaction, and probably the procedures are often not followed. This may have been aggravated by the switch some years ago to the application of insecticides by an automatic device through the air conditioning system. This reduced passenger reaction, and staff lost the habit of using aerosol canisters. The automatic system was stopped on suggestions that it might damage conduits, and the earlier system was inadequately reinstated in some places while many small airlines have always tended to spray inadequately. Though the immediate need is for closer adherence to the regulations, research on possible alternatives, such as residual insecticiding of the cabin contents, is needed.

For the medical reader these cases emphasise the need to keep malaria in mind when confronted with an undiagnosed fever, not only in the recently returned traveller but also when the patient works or lives near an international airport, especially during periods of very hot weather in Europe.

We are grateful to Dr J A Dew and Dr C T A James for referring the patients; Miss C Wells and Miss T Horton for typing help; and all those airport and Sussex environmental health staff who helped with various phases of the investigations.

References

- 1 Bruce-Chwatt LJ. Imported malaria: an uninvited guest. *Br Med Bull* 1982;38:179-85.
- 2 Crockett GS, Simpson K. Malaria in neighbouring Londoners. *Br Med J* 1953;iii:1141-2.
- 3 Curtis CF, White GB. Plasmodium falciparum transmission in England: entomological and epidemiological data relative to cases in 1983. *J Trop Med Hyg* (in press).
- 3a Warhurst DC, Robinson BL, Peters W. The blood schizontocidal action of erythromycin against Plasmodium knowlesi infections in Macaca mulatta. *Ann Trop Med Parasitol* 1983;77:231-7.
- 4 Miller LH. Malaria. In: Weatherall DJ, Ledingham JGG, Warrell DA, eds. *Oxford textbook of medicine*. London: Oxford University Press, 1983:5:393-9.
- 5 Warhurst DC, Curtis CF, White GB. A commuter mosquito's second bite. *Lancet* 1984;ii:1303.
- 6 Ramsdale CD, Coluzzi M. Studies on the infectivity of tropical African strains of Plasmodium falciparum to some southern European vectors of malaria. *Parassitologia* 1975;17:39-44.
- 7 Shute PG. Indigenous P vivax in London believed to have been transmitted by Anopheles plumbeus. *Monthly Bulletin of the Ministry of Health and the Public Health Laboratory Service* 1954;13:48-51.
- 8 Macdonald G. *The epidemiology and control of malaria*. London: Oxford University Press, 1955.
- 9 Dunnet WN, Hacker EJ, MacIntyre A. Report on the investigations into the risks of malaria being brought into the United Kingdom by aircraft carrying live mosquitoes from infected areas. Report to environmental services committee, Crawley Borough Council, 1984.
- 10 Holvoet G, Michielson P, Vandepitte J. Autochthonous Falciparum malaria in Belgium. *Ann Soc Belg Med Trop* 1983;63:111-7.
- 11 Leger N, Pesson B, Bruaire M, et al. Le paludisme des aéroports. Resultats d'une enquête sur les aéroports parisiens. *Med Trop* 1981;41:431-41.
- 12 Anonymous. Malaria surveillance. *WHO Weekly Epidemiological Record* 1978;53:337-8.
- 13 Delamarre BJM, van der Kaay HJ. Malaria tropica op natuurlijke wijze verkregen in Nederland. *Ned Tijdschr Geneesk* 1979;123:1981-2.
- 14 Holvoet G, Michielson P, Vandepitte J. Airport malaria in Belgium. *Lancet* 1982;iii:881-2.
- 15 Weir WRC, Hedges J, Wright J, Higgins A, Corrigan R. Atypical falciparum malaria. *Br Med J* 1984;289:178.
- 16 Smeaton MJ, Slater PJ, Robson P. Malaria from a "commuter mosquito." *Lancet* 1984;ii:845-6.
- 17 Bailey J. *Guide to hygiene and sanitation in aviation*. Geneva: World Health Organisation, 1977.

(Accepted 26 September 1984)