Carlos Finlay: discoverer of the vector of yellow fever

Carlos Juan Finlay, who demonstrated that yellow fever is transmitted by the mosquito *Aedes aegypti*, died 100 years ago, on 20 August 1915. This year marks the centenary of his death.

Yellow fever (or yellow jack, as it was called in earlier times) is a viral disease which occurs widely, but particularly in west Africa and central and south America. It probably originated in Africa and spread to the New World as result of the slave trade. An attack of the disease, if it is survived, confers lifelong immunity, so the resident adult population consists largely of immune survivors. Epidemics of yellow fever were likely to occur among non-immune 'immigrants' into an endemic area, particularly the British and French soldiers and sailors sent out to serve in Africa and the West Indies. There are many examples of British garrisons and of crews of naval ships being all but wiped out by this plague.

Yellow fever has given rise to folk tales and poetry. The legend of the 'Flying Dutchman' is of a spectral ship whose crew had all perished of the disease – the story is the subject of an opera by Wagner. Coleridge's 'Rime of the Ancient Mariner' concerns a ship's crew infected with yellow jack.

Yellow fever, in many cases, runs a mild course, especially in children – a few days of fever, headache, back ache, nausea and vomiting. However, in about 15% of patients the initial symptoms are followed by recurrent fever, abdominal pain, jaundice (as a result of liver damage) and gastrointestinal bleeding – the Spanish name for the disease is 'vomito negro' (black vomit). This toxic phase has a mortality of about one in five patients. Although today there is no specific treatment for this viral disease, there is a very effective vaccine.

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One of the early investigators of this serious, common and widespread disease was Carlos Finlay. Carlos Juan Finlay was born in Cuba (then a Spanish possession), in December 1833. His father was a Scottish physician and his mother of French descent. Carlos was educated in Cuba, London, France and Germany and was multilingual even as a child. He was sent to the USA for his medical studies, to the Jefferson Medical College in Philadelphia, where he qualified in 1855. He continued his postgraduate training in Havana and Paris, then settled in Havana in medical practice.

The first suggestion that the mosquito might, in some way, be connected with the spread of yellow fever was made by Josiah Clark Nott, in Alabama, Georgia in 1848. However, it was Finlay (who began to study and publish on the disease as a young man) who, in 1881, at The International Sanitary Meeting in Washington USA, gave a paper on the mosquito as the vector of the disease. He deduced this from his careful observations on the conditions in areas where yellow fever was common. Furthermore, he narrowed this down to a specific mosquito, now known as *Aedes aegypti* (in fact, the female of the species), which must be the transmitting agent.

Finlay carried out numerous clinical experiments with mosquitoes who had bitten patients with the disease and showed that a mosquito who had sucked the blood of a patient in the early days of the disease could transmit the disease by biting other subjects. He also showed that subjects who had recovered from the disease were not re-infected by the bite of a mosquito who had fed on a diseased patient. In one experiment 90 subjects were bitten by infected mosquitoes; 16 developed a mild attack of the disease. All had subsequent immunity to bites from infected mosquitoes. In all, he published some 70 papers on the disease and its spread.

Unfortunately, little was done at first to implement Finlay's work. In 1898, American soldiers based in Cuba were dying in large numbers from the disease. In 1900, the American government sent a commission to Havana to study the problem. This commission was headed by Walter Reed, Professor of Bacteriology at the Army Medical School, Washington. Reed and his medical team completely confirmed and extended Finlay's observations. They first showed that volunteers, including members of the commission, exposed to the clothes and bedding of infected soldiers, failed to get the disease provided they were housed in a mosquito-proof hut; disinfection was therefore unnecessary in the control of the disease. Bites from the infected *Aedes aegypti* could indeed transmit the illness. There was one fatality during these extensive clinical studies – Jessie William Lazear, a medical member of the commission, died of the disease following a bite from an Aedes mosquito.

Reed gave full credit to Finlay for discovering the yellow fever vector and hence the means of controlling the disease by the eradication of the mosquito breeding sites. This work was carried out by William Gorgas, a major in the US Medical Corps, who was sent to Havana as Chief Sanitary Officer in 1898. It was Gorgas, sent to Panama in 1904, whose sanitary work eliminated the scourge of yellow fever in Panama and made possible the construction of the Panama Canal.

Carlos Finlay was appointed chief medical officer for Cuba in 1902 and served until 1909. As well as yellow fever, he published papers on his work on leprosy and cholera. There is a statue honouring him in Havana and, interestingly, another in Panama City, acknowledging that his work helped make construction of the canal possible.

Finlay died at his home in Havana of a stroke 100 years ago, at the age of 81 years, certainly the most famous medical son of Cuba. BJHM

Conflict of interest: none.