Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

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COVID-19 and *Plasmodium falciparum* co-infection in a man returning from Cameroon

Dear Editor,

The coronavirus infection 2019 (COVID-19), which is caused by SARS-CoV-2, pandemic with a spectrum of illness from asymptomatic to multiorgan dysfunction and death. Typical presentations of COVID-19 are respiratory, including fever, cough, flu-like symptoms, and shortness of breath. Some cases also exhibiting cardiac, gastrointestinal, neurological or renal manifestations [1]. As SARS-CoV-2 spreads globally, some patients will be infected with both the SARS-CoV-2 virus and other prevalent or endemic pathogens [2].

Malaria is a major cause of morbidity and mortality in the tropics. *Plasmodium falciparum* is responsible for most of the malaria burden, and *P. vivax* is the most widespread cause of malaria [3]. Symptoms of malaria include fever, chills, body-aches, headache, cough, and diarrhea [4].

Some symptoms of malaria are similar to those of COVID-19, making it harder to diagnose both diseases. Herein, we described a case of COVID-19 and *P. falciparum* co-infection in a man returning from Cameroon. We also discussed the challenges posed by the COVID-19 pandemic to global malaria control.

A 48-year-old male worked from August 2019 to August 2021 in Douala, Cameroon. He returned to China from Cameroon in August 2021. Two days after returning to China, the patient developed fever (40 °C) of unknown cause, accompanied by chills, headache, dizziness, body ache, fatigue, and poor appetite. The fever was relieved after self-administration of antipyretics. The patient did not have cough, expectoration, nausea, vomiting, diarrhea, abdominal pain, palpitations, or chest tightness. He reported a history of malaria in half a year ago, treated successfully with antimalarial drugs. After 1 day of fever, he presented to The Second Affiliated Hospital of Guangzhou Medical University in Guangzhou for isolation and treatment.

On physical examination, his blood pressure was 116/68 mm Hg, breathing was smooth, skin and mucous membranes were normal, no skin rash, heart and lung auscultation was normal, the abdomen was normal, and lower limbs had no edema. Laboratory investigations of blood showed serum glucose was 13.74 mmol/L (Normal 3.89–6.11 mmol/L) (The patient was reported to have no history of diabetes), serum K+ was 2.80 mmol/L (Normal 3.5–5.3 mmol/L), serum Na+ was 126.0 mmol/L (Normal 137–147 mmol/L), and serum Cl-was 91.0 mmol/L (Normal 99–110 mmol/L); Prothrombin time was 15.2 seconds (Normal 9.2–15 seconds), fibrinogen concentration was 4.07 g/L (Normal 2–4 g/L), and D-dimer concentration was 1.97 mg/L (Normal 0–0.55 mg/L); White blood cells count was 3.0×10^9/L (Normal 3.5–9.5 $\times$ 10^9/L), lymphocyte count was 0.69×10^9/L (Normal 1.10–3.20 $\times$ 10^9/L), and eosinophil count was 0.01×10^9/L (Normal 0.02–0.52 $\times$ 10^9/L) (Table 1). No obvious abnormality was observed in liver, bile, pancreas, and spleen. Chest X-ray revealed multiple microscopic nodules, which were suspected to be chronic inflammatory granuloma, and the patient was recommended for regular review. The patient's liver examination showed fatty liver.

Given the possibility of malaria, the patient was tested for malaria. The malaria rapid antigen test showed *P. falciparum* infection, the diagnosis was *P. falciparum* malaria. Subsequently, the patient was treated with artesunate. Meanwhile, the patient was treated for electrolyte disorder. On the day of admission, a nasopharyngeal swab was sent for SARS-CoV-2 RT-PCR. The day after admission, his SARS-CoV-2 nasopharyngeal swab was reported as positive. The patient was started on treatment based on the COVID-19 management protocol at the time. Three days after admission, the patient did not have fever after treatment, and the related symptoms improved. The patient did not cough, cough sputum, nausea, vomiting, palpitations, chest tightness, diarrhea, or abdominal pain. The patient continued to receive routine treatment for COVID-19 and anti-malarial treatment.

On the 12th day after admission, the patient was in good spirits, without fever, headache, dyspnea, chest pain or palpitations. Lung and abdominal tests were normal. The result of RT-PCR detection of SARS-CoV-2 was negative and plasmodium falciparum test was negative. He was discharged and kept in isolation for two weeks after discharge.

P. falciparum and *P. vivax* are the predominant species worldwide with an estimated incidence of 207 million and 8.5 million cases, respectively, in 2016 [4]. Most falciparum malaria occurs in sub-Saharan Africa (about 190 million cases), where transmission remains severe in many places [5,6]. The COVID-19 pandemic will bring new challenges to the diagnosis of malaria and COVID-19. One is that the two diseases have similar symptoms; Second, the COVID-19 pandemic has exacerbated a shortage of medical resources, leading to a disruption of routine malaria diagnosis. In malaria-endemic areas, clinicians should be aware of the possibility of COVID-19 and *P. falciparum* co-infection. In non-malaria-endemic areas, clinicians should ask patients if they have a history of travel to malaria-endemic areas. At present, there is no relevant report on whether COVID-19 and malaria co-infection will aggravate the patient's condition, but accurate diagnosis of co-infection and active treatment should be mastered by clinicians.

Ethics approval and consent to participate

We obtained written consent to publish this case report from the patient.

Declaration of competing interest

The authors have no conflicts of interests or disclosures to declare.

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Table 1
Laboratory values in a COVID-19 and *Plasmodium falciparum* co-infection case.

Laboratories	Result	Units	Ref. values
Glucose	13.74 (H)	mmol/L	3.89–6.11
Creatinine	78.00	μmol/L	62–115
Urea	3.5	mmol/L	2.86–8.2
K+	2.80 (L)	mmol/L	3.5–5.3
Na+	126.0 (L)	mmol/L	137–147
Cl-	91.0 (L)	mmol/L	99–110
CALC	1.91 (L)	mmol/L	2.08–2.8
Triglyceride	2.45 (H)	mmol/L	0.5–1.7
Cholesterol	2.14 (L)	mmol/L	3.15–5.7
Apolipoprotein A1	0.33 (L)	g/L	1.2–1.8
Apolipoprotein B	0.73	g/L	0.6–1.41
High density lipoprotein cholesterol	0.22 (L)	mmol/L	0.94–1.54
Low density lipoprotein cholesterin	1.39 (L)	mmol/L	1.5–3.37
Lipoprotein a	672 (H)	mg/L	0–300
Total bilirubin	16.2	μmol/L	6.0–22.0
Direct bilirubin	4.2	μmol/L	0.0–6.8
Alanine aminotransferase	31	U/L	9–50
Aspartic transaminase	33	U/L	15–40
Gamma-glutamyl transpeptidase	33	U/L	0–60
Alkaline phosphatase	92	U/L	45–125
Total protein	62.7 (L)	g/L	65–85
Albumin	36.8 (L)	g/L	40–55
Prealbumin	134.18 (L)	mg/L	200–400
Total bile acid	0.4	μmol/L	0–10
Adenosine deaminase	34.3 (H)	U/L	4–22
Cholinesterase	6305	U/L	5000–12000
α-L-fucosidase	22.1	U/L	14.3–39.9
Globulin	25.9	g/L	20–40
Indirect bilirubin	12.0	μmol/L	1.0–20.0
WBC	3.0 (L)	× 10^9/L	3.5–9.5
Lymphocyte	0.69 (L)	× 10^9/L	1.10–3.20
Monocyte	0.28	× 10^9/L	0.10–0.60
Eosinophils	0.01 (L)	× 10^9/L	0.02–0.52
Basophilic granulocyte	0.02	× 10^9/L	0–0.06
RBC	4.56	× 10^12/L	4.3–5.8
Platelet	94 (L)	× 10^9/L	125–350
Prothrombin time	15.2 (H)	s	9.2–15
Activated partial thromboplastin time	33.3	s	21–37
Thrombin time	16.7	s	10–20
D-Dimer	1.97 (H)	mg/L	0–0.55
Fibrinogen	4.07 (H)	g/L	2–4

H (high), L (low).

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