Multiple organ dysfunction due to heatstroke after sauna: case report and review of the literature

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Introduction
Heatstroke is a life-threatening illness characterised by an elevated core temperature of \( >40^\circ\text{C} \) and dysfunction of the central nervous system, resulting in delirium, convulsions and coma. Here, we report an unusual case of heatstroke-induced multiple organ dysfunction syndrome after sauna in winter.

Case
A 26-year-old Chinese man who worked as a salesman was admitted to Jiangsu Province Hospital of Traditional Chinese Medicine for coma and convulsion in January 2013. Until admission, he had taken sauna for 30 to 60 min. A waiter found him staggering in the corridor and then he fell into the water. He was rescued immediately and moved to a test room, where he developed convulsions lasting for 30 s. Prior to his admission, he was robust and never developed convulsions. What’s more, no abnormal findings had been detected on routine physical examinations and laboratory testing. His initial evaluation showed consciousness disturbance and a Glasgow Coma Scale level of 8 (E2V2M4). The axillary temperature was 40.0 °C. His blood pressure was 118/64 mmHg, and his heart rate was 140 beats/min. His respiratory rate was 32 breaths/min.

The initial laboratory test findings are shown in Table 1. Abnormal findings comprised serum creatinine 197.8 μmol/L, creatine kinase 1600 U/L and white blood cell count 16.0 × 10⁹/L. Except for fever and white blood cell count 16.0 × 10⁹/L, there were no abnormal findings leading to the development of consciousness disturbance. A computed tomography scan of our patient’s head failed to show any abnormal findings.

Based on these findings, the patient was admitted to neurology. The initial treatment comprised cooling, intravenous fluid and antibiotics administration. We administered 3500 mL of normal saline intravenously during the first day. His urine output was 2000 mL during the same period. After the above treatment, our patient’s core body temperature returned from 40.0 °C to 38.2 °C, but his levels of consciousness did not recover, and he developed breathing difficulties. He was transferred to the intensive care unit. His evaluation showed consciousness disturbance and a Glasgow Coma Scale level of 8 (E2V2M4); the axillary temperature was 38.6 °C. The laboratory test findings, shown in Table 1, were considered to exist acute renal injury with acute hepatic failure and disseminated intravascular coagulation as shown in Table 1. He met the criteria for multiple organ dysfunction syndrome. The instant treatment comprised cooling, intravenous fluid administration, continuous renal replacement therapy, tracheal intubation and mechanical ventilation. At first, second and third days in the intensive care unit, we obtained blood and sputum cultures, and the results were negative. We also gave the patient a lumbar puncture at first day, and the result was negative too. No signs suggesting the presence of sepsis were documented.

On the seventh day, he became fully conscious. His body temperature returned to normal (36.9 °C). His general condition improved, the serum creatinine, creatine kinase, aspartate aminotransferase, alanine aminotransferase, lactate dehydrogenase levels and white blood cell count began to drop and he was discharged on the 30th day. After discharge, the patient completely recovered, without any organ dysfunction during 36 months of follow-up.
In the present case, we report a young patient with severe heatstroke after sauna with multiple organ dysfunction. The heatstroke in our patient’s case was probably preceded by higher environmental temperature and humidity of sauna. Clinicians need to consider the possibility of heatstroke when patients had hyperthermia and dysfunction of the central nervous system after they stayed or worked in the place with higher environmental temperature and humidity even without strenuous exercise, or even in winter.

There are two types of heatstroke: classic and exertional. Classical type affects individuals, most often infants or older patients who are suffering from diabetes, congestive heart failure, malnutrition or dehydration. The exertional heatstroke generally occurs in younger people, due to heavy exercise scenarios under sustained environmental heat and humidity especially when the humidity is high. Our patient suffered hyperthermia, convulsion and coma just after 30 to 60 min sauna without heavy exercise, which may be attributed to the high temperature and humidity of sauna room. When the ambient temperature is higher than the body temperature,

| Laboratory finding | 1st Day | 2nd Day | 3rd Day | 4th Day | 7th Day | 10th Day | 28th Day | 60th Day |
|--------------------|---------|---------|---------|---------|---------|----------|----------|----------|
| WBC count (10^9/L) | 16      | 27.9    | 31.1    | 40.5    | 23.2    | 28.9     | 8.9      | 6.55     |
| Haemoglobin (g/L)  | 130     | 136     | 119     | 146     | 120     | 91       | 84       | 101      |
| Platelet count (10^7/L) | 223 | 52      | 34      | 10      | 34      | 151      | 208      | 131      |
| PT (s)             | 15.3    | 19.9    | 58.8    | 53.7    | 18.1    | 14.2     | 14.3     | 14.3     |
| APTT (s)           | 36.4    | 58      | 88.3    | 61.3    | 45.2    | 42.5     | 54.8     | 14.3     |
| Fibrinogen (g/L)   | 2.2     | 1.53    | 0.8     | 0.85    | 1.77    | 3.63     | 2.62     |          |
| D-dimer level (mg/L) | 0.93 | 4.0     | 4.0     | 4.0     | 4.0     | 4.0      | 4.0      | 4.0      |
| Blood urea nitrogen (mmol/L) | 7.2 | 12.4    | 18.4    | 14.2    | 10.93   | 13.9     | 14.37    | 5.49     |
| Creatinine (μmol/L) | 197.8  | 406.5   | 788.3   | 501.2   | 247.3   | 249.2    | 409.3    | 124.2    |
| Serum sodium (mmol/L) | 146   | 141     | 146.2   | 145.7   | 141.0   | 136.8    | 139.5    | 139.4    |
| Serum potassium (mmol/L) | 4.59 | 3.7     | 4.04    | 4.58    | 5.04    | 3.84     | 3.9      | 4.1      |
| AST (U/L)          | 65      | 597     | 3100    | 8012    | 1659    | 291      | 52       | 35       |
| ALT (U/L)          | –       | 145     | –       | 9294    | 2860    | 530      | 90       | 72       |
| TBil (µmol/L)      | –       | 24.7    | –       | 134.7   | 261.1   | 152.6    | 12.9     | 11.9     |
| LDH (U/L)          | 1013    | –       | 1949    | 12424   | 7970    | 753.1    | 542.5    | –        |
| CK (U/L)           | 1600    | –       | 27340   | 85288   | 145907  | 6769     | 1705     | –        |
| CK-MB (U/L)        | 33      | –       | 8200    | 783     | 573     | 62       | 123      | –        |
| cTnI (ng/ml)       | –       | 4.11    | –       | 2.20    | 0.58    | 0.16     | –        | –        |
| FiO2 (%)           | –       | 40      | –       | –       | 41      | –        | –        | –        |
| PaO2 (mmHg)        | –       | 192     | –       | 135     | –       | –        | –        | –        |
| PaCO2 (mmHg)       | –       | 36      | –       | 35      | –       | –        | –        | –        |

WBC: white blood cell; PT: prothrombin time; APTT: activated partial thromboplastin time; AST: aspartate aminotransferase; ALT: alanine aminotransferase; LDH: lactate dehydrogenase; CK: creatine kinase; CK-MB: creatine kinase-MB; cTnI: cardiac troponin I; PaCO2: partial pressure of carbon dioxide; FiO2: fraction of inspired oxygen.
sweating accounts for almost all of heat loss, but when the humidity was too high, sweating became inefficient, and hyperthermia occurred.6 Heatstroke can be classified as a form of systemic inflammatory response syndrome with multiple organ dysfunction; the mortality remains high and many patients inevitably develop permanent neurologic damage.8 The mechanism underlying multiple organ dysfunction syndrome of heatstroke is not fully understood, but direct thermal injury to the endothelium, activation of the inflammatory and coagulatory pathways, tissue ischaemia and/or endotoxemia and cytokines have been suggested.9,10 The key measures to maximise the survival chances of heatstroke patients are as follows: rapidly decreasing the elevated core body temperature and organ support of central nervous system, cardiovascular, pulmonary, renal system and the management of late or post-cooling complications.11–13 After admission, our patient presented with acute renal injury, acute hepatic failure, skeletal muscle damage and disseminated intravascular coagulation soon. We used cooling blankets and ice packs covering parts of the body, commonly in proximity to large vessels (that is, neck, groin and axillae) and continuous renal replacement therapy to decrease body temperature quickly. When our patient’s body temperature returned to normal (36.9°C), his general condition improved.

Sauna is very popular in winter, under many circumstances, the temperature of the sauna room approaches and exceeds 100°C, which would be completely intolerable. The modern saunas overcome this problem by controlling the humidity. By pouring water on the hot stones, the air temperature could be tolerated. If the humidity is higher, heatstroke may happen. The onset of heatstroke is often acute without prodromal signs but can be gradual with non-specific symptoms of weakness, dizziness, fainting, nausea, vomiting, headache and restlessness or confusion.6 Neurological alteration is a main characteristic feature of heatstroke, so when patients exhibit mental status changes such as delirium, deep coma or seizures after sauna in any seasons, clinicians should consider the possibility of heatstroke.

Declarations
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