Case Report

Caffeine poisoning successfully treated by venoarterial extracorporeal membrane oxygenation and emergency hemodialysis

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Background: Caffeine overdose can cause life-threatening circulatory failure, neurological abnormalities, and ventricular fibrillation. We report the case of a patient with caffeine poisoning who was successfully treated with early hemodialysis and venoarterial extracorporeal membrane oxygenation.

Case Presentation: A 43-year-old man who had ingested pills containing 20 g caffeine was transported to the hospital 100 min after ingestion. Hemodynamic collapse and refractory arrhythmia were most likely the potential complications. The patient developed ventricular fibrillation when placed in the left lateral decubitus position. Return of spontaneous circulation with defibrillation and introduction of venoarterial extracorporeal membrane oxygenation were followed by emergency dialysis, which led to rapid improvement in the clinical findings.

Conclusion: Acute caffeine poisoning in a patient who developed an arrhythmia was successfully treated using an indwelling arterial and venous sheath followed by venoarterial extracorporeal membrane oxygenation.

Key words: arrhythmia, caffeine, hemodialysis, venoarterial extracorporeal membrane oxygenation, ventricular fibrillation

INTRODUCTION

Caffeine overdose can cause lethal arrhythmias, which are often refractory.1 There are several case reports in which hemodialysis was effective for refractory arrhythmias caused by caffeine poisoning in the context of suicide, and hemodialysis is becoming common as a means of treatment in other contexts.2 There are currently few case reports in which patients who developed arrhythmias were saved using venoarterial extracorporeal membrane oxygenation (VA-ECMO); furthermore, to the best of our knowledge, no other study has reported on a shorter time used to initiate VA-ECMO for caffeine poisoning compared to that reported in our study, with a subsequent arrhythmia corrected using an indwelling arterial and venous sheath and VA-ECMO.

CASE PRESENTATION

A 43-YEAR-OLD MAN with a 20-year history of bipolar disorder attempted suicide by ingesting pills containing 20 g caffeine. He arrived at our hospital 100 min after ingestion. Vital signs included: respiratory rate, 30 breaths/min; SpO2, 97% (ambient air); heart rate, 130 b.p.m.; blood pressure, 126/69 mmHg; and Glasgow Coma Scale score, E4V5M6. The patient had 10 bouts of watery vomit. He was 176 cm tall and weighed 60 kg.

Premature ventricular contractions were observed on electrocardiography (Fig. 1). Blood examination revealed: white blood cell count, 7500/μL; creatine phosphokinase, 66 IU/L; and potassium, 2.6 mEq/L. Arterial blood gas analysis revealed respiratory alkalosis and metabolic acidosis: pH 7.43; PCO2, 27.3 mmHg; PO2, 124 mmHg; HCO3, 17.7 nEq/L; and lactate, 6.5 mmol/L. He had ingested 333 mg/kg of caffeine, with blood levels showing 42 μg/mL (poisoning range ≥25 μg/mL) 2 h after ingestion. Blood
theophylline levels, a metabolite of caffeine, were at or below measurement sensitivity (poisoning range ≥20 μg/mL). Although a normal blood pressure at arrival was maintained, a wide QRS complex and a pulse rate of 130 b.p.m. were observed.

At 50 min after arrival, a flexible double-lumen catheter was placed in the right internal jugular for emergency hemodialysis. Sixty minutes after arrival, when the arrhythmia occurred, a catheter sheath was placed in the right femoral vein and left femoral artery to enable rapid introduction of extracorporeal membrane oxygenation (ECMO). Sixty-five minutes after arrival, midazolam (10 mg), fentanyl (0.1 mg), and rocuronium (50 mg) were used to initiate tracheal intubation and artificial respiratory management. Eighty minutes after arrival, when he was placed in the left lateral decubitus position during endoscopy, he developed pulseless ventricular tachycardia. Eighty-two minutes after arrival, chest compressions and defibrillation yielded successful return of spontaneous circulation; however, he developed ventricular fibrillation. Eighty-five minutes after arrival, VA-ECMO was introduced from the sheath catheter site, ensuring a blood supply of 3.5 L/min at 2000 rpm. Because potassium levels were low, they were replenished, which eliminated premature ventricular contractions. One hundred minutes after arrival, hemodialysis was introduced at a flow rate of 100 mL/min from the flexible double-lumen catheter and a dialysate flow rate of 4000 mL/h. After hemodialysis, the patient’s tachycardia began to improve. Sixteen hours after arrival, the premature ventricular contractions decreased and hemodialysis was terminated. The premature ventricular contractions did not reappear after termination of dialysis, and his heart rate maintained a sinus rhythm at 90 b.p.m. Dialysis was terminated when the PaO2/FiO2 ratio was at 450 mmHg, and the patient was weaned off ECMO. On hospital day 2, ECMO was...
terminated when the patient had a heart rate of 70 b.p.m.,
blood pressure of 130/80 mmHg, respiration rate of 16
breaths/min, and electrocardiographic waveform with sinus
rhythm, suggesting he had escaped the acute poisoning state
(Fig. 2). He also returned to a lucid state of consciousness.
Extubation was carried out on hospital day 4, and the serum
caffeine level was 5.5 μg/mL, with a serum theophylline
level of 3.7 μg/mL (Fig. 2). Rehabilitation was started on
the day of extubation, and he was transferred to a psychiatric
hospital on day 21.

DISCUSSION

THE HALF-LIFE OF caffeine in the human body blood
is 3–7 h in adults but is reportedly up to 16 h in the
case of an overdose. The lethal dose is ≥150 mg/kg for an
adult, with blood levels ≥70 μg/mL. Caffeine levels have
been estimated by measuring serum theophylline, a metabo-
lite of caffeine, but only 4% of caffeine is metabolized to
theophylline, and possibly none in the early stages after
ingestion. The theophylline levels in this case were also
below the detection level, and although levels had risen by
hospital day 4, they were not useful for estimating caffeine
levels or for devising a treatment plan. In the acute stages of
caffeine poisoning, it might not be useful to measure theo-
phylline levels for estimating caffeine levels.

Caffeine poisoning is frequently refractory, and hemodial-
alysis is reported to be effective for lowering blood caffeine
levels. Caffeine has a protein binding rate of 36%, a molec-
ular weight of 194, and a volume of distribution of 0.6–
0.8 L/kg, which is relatively low, thereby increasing the
effectiveness of hemadsorption and hemodialysis. The most
common cause of death from caffeine poisoning is lethal
arrhythmia, which persists until blood caffeine levels
decrease. The use of VA-ECMO and hemodialysis to save a
patient’s life after refractory arrhythmia due to caffeine poi-
soning was recently published.

As caffeine has a wide range of reported serum concentra-
tions and because Japan has few facilities capable of mea-
suring caffeine levels, treatment strategies should be
determined based on caffeine poisoning in terms of either
milligrams per kilogram of body weight or the absolute
amount ingested.

If the amount of caffeine ingested has exceeded 150 mg/
kg or 6.0 g, it would be preferable to combine hemodialysis
and catheter sheath placement for VA-ECMO until symp-
toms improve. Catheter sheath placement is a relatively easy
operation, but the difficulty increases when cardiac arrest or
shock occurs. In this case, a catheter sheath was implanted
for VA-ECMO at the time of diagnosis of caffeine intoxica-
tion. This is the first study to report on such a rapid decision

| Table 1. Comparison of results of previous studies on caffeine poisoning, treated using venoarterial extracorporeal membrane oxygenation (ECMO), with those of our study |
|---|---|---|---|---|---|---|---|---|
| Case no. | Author (year) | Ingested dose (mg) | Caffeine per kg (mg/kg) | Serum concentration (μg/mL) | Arrhythmia | Catheter sheath placement before cardiac arrest | VA-ECMO time after arrival (min) | VA-ECMO initiation time after arrival (h) |
| 1 | Riku (2018) | 12,000 | Unknown | 172.0 | VF | Yes | 1.2 | 12 |
| 2 | Kato (2019) | 15,360 | 190 | 251.9 | VF | None | Right peroneal nerve paralysis | None |
| This case (2020) | 20,000 | 333 | 66.0 | 1.6 | VF | Yes | 85 |

F, female; M, male; VF, ventricular fibrillation.

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to carry out VA-ECMO (Table 1). Lethal arrhythmia from caffeine is refractory and the chances of survival are extremely low unless extracorporeal life support is provided, specifically if extracorporeal cardiopulmonary resuscitation is undertaken. Extracorporeal cardiopulmonary resuscitation with prompt VA-ECMO reportedly also improves neurological prognosis.

**CONCLUSIONS**

We presented a case of acute caffeine poisoning in a patient successfully treated with hemodialysis and VA-ECMO. Our results suggest that advance placement of catheter sheaths for VA-ECMO can be beneficial in cases of caffeine poisoning.

**DISCLOSURE**

Approval of the research protocol: N/A.
Informed consent: Verbal and written informed consent was obtained from the patient.
Registry and registration no. of the study/trial: N/A.
Animal Studies: N/A.
Conflict of interest: None.

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