Uncontrollable hyperthermia in acute cerebral injury
— A Case report —

Department of Anesthesiology and Pain Medicine, Inje University College of Medicine, Busan, Korea

Wonjin Lee, Young Hwan Kim, Seung Su Kim, Kwang-Rae Cho, Sang-Eun Lee, Se Hun Lim, Jeong Han Lee, Kun Moo Lee, Soon Ho Cheong, Young-Kyun Choe, Young-Jae Kim, and Chee-Mahn Shin

A 39 year old man arrived at the hospital with semi-comatose state as a result of spontaneous intracerebral hemorrhage (ICH), intraventricular hemorrhage (IVH) and subarachnoid hemorrhage (SAH). For emergency craniectomy and hematoma removal, general anesthesia with desflurane and vecuronium was planned. Before the induction of anesthesia, the body temperature and end-tidal carbon dioxide (ETCO2) levels were 38.3°C and 38 mmHg, respectively. The body temperature and ETCO2 increased during surgery. After 2 hours of anesthesia, the temperature had increased to 41°C, despite bladder irrigation and body cooling. After 3 hours of anesthesia, the temperature reached 43.5°C and cardiac arrest developed. Cardiopulmonary resuscitation was attempted, but the patient expired.

Key Words: Cerebral injury, Hyperthermia, Intracerebral hemorrhage.

Hyperthermia, whatever the cause, invites detrimental effects on patients. Possible causes of hyperthermia under anesthesia include infection, inflammation, drug reaction and malignant hyperthermia. Central hyperthermia arrives from unknown cause, but it is common after cerebral infarction, cerebral injury and intracerebral hemorrhage [1-3]. We report a case of uncontrollable hyperthermia with acute cerebral hemorrhage during general anesthesia.

CASE REPORT

A 39-year-old, 85 kg man arrived hospital with unconsciousness. He had fallen over the hallway. At arrival on hospital, patient was semicomatous and brain computerized tomography (CT) showed ICH, IVH, SAH (Fig. 1). No fracture of skull was seen on brain CT. His medical history was unremarkable. For emergency craniectomy and hematoma removal, general anesthesia with desflurane and vecuronium was planned. Preoperative neurologic examination revealed anisocoria (right, 5 mm; left, 2 mm), and no light reflex on right eye. Endotracheal intubation was performed at emergency room.

The patient was premedicated with 0.2 mg of glycopyrrolate...
Anesthesia was induced with 50 mg of propofol IV, and 7 mg of vecuronium IV. After the induction of anesthesia, right subclavian vein and radial artery catheters were placed. At this point, the arterial blood gas was pH 7.315, PaO$_2$ 100 mmHg, PaCO$_2$ 43 mmHg, base excess $-0.7$ mmol/L. Anesthesia was maintained with desflurane (under 1 minimum alveolar anesthetic concentration) in oxygen, remifentanil (range, 0.1 $-$ 0.2 $\mu$g/kg/min) and additional vecuronium. Controlled ventilation was provided with tidal volume 800 ml, respiration rate (RR) 12 bpm. FiO$_2$ was 0.5 and N$_2$O was not used during the maintenance of anesthesia.

Preoperative vital signs were: arterial blood pressure, 140/110 mmHg; Heart rate, 80 rate/min; esophageal temperature, 38.3°C; and end-tidal carbon dioxide (ETCO$_2$), 38 mmHg respectively. We administrated 30 mg of ketorolac IV at incision time, nevertheless body temperature and ETCO$_2$ increased in process of surgery (Fig. 2). At 60-min post induction of anesthesia, esophageal temperature and ETCO$_2$ reached to 39.0°C and 40 mmHg respectively. The arterial blood gas showed: pH 7.253, PaO$_2$ 156 mmHg, PaCO$_2$ 52 mmHg, base excess $-1.3$ mmol/L. We informed to surgeon and discussed about whether to continue operation. Surgeon wanted to continue operation strongly, so desflurane was stopped and 100% oxygen was supplied to patient. We raised RR to 18 bpm and therapy for hyperthermia was initiated, including bladder irrigation with cold saline, cold IV fluid, icepack on both axillar and inguinal area, and external cooling with alcohol. These efforts to decrease body temperature were continued until the operation was over. Because we don’t have in stock of dantrolene, we requested dantrolene to other hospital. At 115-min post induction of anesthesia, surgeon opened the dura mater. Brain tissue came out of the cranium due to severe brain swelling. Esophageal temperature was raised acutely over 41°C and blood pressure was started to decrease. At 150-min post induction of anesthesia, blood pressure decreased under 80/55 mmHg. Infusion of dobutamine and epinephrine was started and desflurane was stopped. The arterial blood gas showed severe acidosis: pH 6.938, PaO$_2$ 128 mmHg, PaCO$_2$ 103 mmHg. Therapy for acidosis was performed, including hyperventilation (as mentioned above), repeat administration of 80 mEq of bicarbonate IV. At 160-min post induction of anesthesia, despite of administration 2 mg of epinephrine IV bolus, blood pressure was continued to decrease to 55/30 mmHg and cardiac arrest was developed. We demanded surgeon to stop the operation and started cardiac massage. But patient showed no response. At 180-min post induction of anesthesia, patient moved to ICU with cardiac massage. After 30 minutes of CPR in ICU, we declared expiration.

**DISCUSSION**

Because of detrimental effects of hyperthermia, it must be treated. Hyperthermia leads to increase in oxygen consumption. If increased oxygen demand exceed supply, it may cause metabolic acidosis, and furthermore hypotension. Hypotension can be caused by direct hyperthermic vasodilation. Activities of many enzymes and drug metabolism are altered. Beside these, hyperthermia induces many unknown effects on human body.

Fever is common among patients with severe neurologic illnesses, such as strokes or traumatic brain injuries. Even moderate temperature elevations soon acute cerebral damage may markedly worsen initial brain injury. Fever is usually treated by antipyretic drugs and external cooling. An alternative method for temperature management may be an intravascular approach.

In patients with spontaneous intracerebral hemorrhages, a correlation between the duration of the fever and the poor outcome was documented [1]. These effects may justify aggressive antipyretic therapy in neurosurgical patients. Maintenance of normothermia appears to be a desirable therapeutic goal in managing the patients with damaged brain tissue. However, it has not been established conclusively that the benefits of antipyretic treatment outweigh its risks. But, we at-

---

**Fig. 2.** The graph represent the body temperature (BT) and mean blood pressure (MBP) after induction of anesthesia. Arrow reflects the point of time for severe brain swelling.
The causes of fever during general anesthesia are diverse; infection, inflammatory reaction, malignant hyperthermia, thyroid storm, accumulation of heat due to surgical drape, sympathetic storm, and central origin hyperthermia. In this case, not enough evaluation was done because of emergency and patient’s death. Hence we cannot declare the cause of patient’s fever. But steep elevation of body temperature was occurred immediately after brain swelling, so we think the possibility of central hyperthermia is high.

Central hyperthermia result from damage to the thermoregulatory centers of the hypothalamus [4]. Central fever related to loss of the physiological regulation of body temperature by the hypothalamus is often proposed as a possible cause for persistent fever in acute neurological patients with no evidence of infection. But, there are no current means to confirm the diagnosis of central fever.

Correlation of fever with hemorrhage volume and third ventricular shift suggests a possible role of hypothalamic compression in “central fever” after ICH [5]. Many previous studies show the incidence of hyperthermia is frequent in patients with ICH. In 1935, Aring and Merrit were the first to report that fever is more frequent in patients with hemorrhagic stroke than ischemic stroke [6]. The study by Schwarz et al. shows incidence of hyperthermia after ICH is high, and in company with intraventricular hemorrhage (IVH) or subarachnoid hemorrhage (SAH) the risk of hyperthermia increase more [1]. In this case, patient showed fever before induction of anesthesia, and body temperature raised acutely after severe brain swelling. Therefore it might be cerebral origin hyperthermia.

Diagnosis of central hyperthermia made by exclusion other causes of hyperthermia. However we could not rule out other causes of hyperthermia as mentioned above. In this case, desflurane was used to maintain anesthesia. Desflurane have potential to occur malignant hyperthermia (MH) [7,8]. Desflurane can trigger MH without the use of succinylcholine. Our patient had a clinical grading scale of 38 (grade D5). Grades D5 (very likely) and D6 (almost certain MH) are defined by scores of 35−49 and ≥50, respectively. The clinical grading scale uses six process indicators and a seventh “other” category indicator: rigidity, muscle breakdown, respiratory acidosis, temperature increase, cardiac involvement, family history, and “indicators not part of a single process” with 3−15 points awarded to subcategories of each indicator [9]. Like malignant hyperthermia, the other causes of hyperthermia cannot be rule out.

In this case, because of not enough evaluation, the cause of hyperthermia was not clear. But hyperthermia is more often in patient with ICH or acute brain injuries. So, anesthesiologist must consider the possibility of hyperthermia in ICH patient and attempt to lower body temperature of hyperthermic patient immediately.

REFERENCES