In Reply.—Dr. Katz is concerned that commercial manipulation of national media is placing undue pressure on anesthesiologists with respect to their use of a new brain-monitoring technology introduced by Aspect Medical Systems. Although it is true that the company has a product to sell, it is probably incorrect to assume that it has "created de novo" the widespread public interest in unintended intraoperative awareness. In fact, intraoperative awareness emerged as a problem in the earliest days of general anesthesia, and the incidence of this problem may have increased in recent years with the increased use of muscle relaxants, high-dose opioid techniques, and total intravenous anesthetics. A survey published in 1990, long before Aspect Medical Systems began developing the current monitor, revealed that 50% of perioperative patients were concerned about intraoperative awareness. The same year also saw the first International Symposium on Memory and Awareness in Anesthesia. In 1994, the October issue of the ASA Newsletter was devoted to the topic of patient awareness and featured an emotional description of a case by a patient who subsequently formed an independent patient support and advocacy group.

At present, large, controlled clinical trials designed to determine exactly how effective the Bispectral Index monitor is in preventing unintended intraoperative awareness in surgical patients have not been performed. There are now, however, more than 40 peer-reviewed papers and in excess of 100 abstracts on the bispectral index and anesthesia or sedation from which an anesthesiologist might draw inference regarding its clinical usefulness. The purpose of my recent review was to facilitate additional research into the effectiveness of the Aspect Medical Systems monitor and other electroencephalography-based devices by providing insight into the relevant theory of operation.

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Acute Severe Hemodilution to a Hemoglobin of 1.3 g/dl Tolerated in the Presence of Mild Hypothermia

To the Editor.—Because the untoward consequences of perioperative mild hypothermia (33–35.5°C), e.g., myocardial ischemia in the recovery period, have received most of the attention lately, it is important to reemphasize that intraoperative mild hypothermia may be advantageous in providing substantial central nervous system and myocardial protection during severe anemia. Lowering body temperature 2 or 3°C reduces overall oxygen consumption and cerebral metabolic rate by 12–20%. In addition, the degree of cerebral protection afforded by mild hypothermia is often much greater than can be accounted for by the aforementioned reduction in cerebral metabolic rate. This may have therapeutic potential when unintentional, extreme hemodilution suddenly occurs secondary to massive surgical blood loss.

Our case was a 61-yr-old, 65 kg woman anesthetized with isoflurane, fentanyl, and pancuronium for a proximal femur resection and composite allograft placement because of renal cell tumor metastasis. She lost 91 blood within 30 min with a further 24 blood loss over the next 25 min. Because only 2 U blood were readily available, intravascular volume resuscitation was initially accomplished with 3 L crystalloid and 8 L albumin, 5%, and then further colloids as needed. Despite vascular volume replacement with colloid exceeding measured blood loss and periodic boluses of phenylephrine and calcium chloride, the systolic blood pressure averaged only 65–70 mmHg with two transient episodes of 55 mmHg during the approximately 1 h of mostly non-blood fluid administration (figure 1). The hemoglobin concentration of the first arterial blood sample drawn from the arterial catheter (approximately 35 min after the start of the volume resuscitation) was 1.3 g/dl and approximately 40 min later was 8.6 g/dl after transfusion of 7 to 8 U of packed erythrocytes. Because the administration of these packed red blood cells was not started until 20 min after the 1.3 g/dl hemoglobin sample had been drawn and blood loss had slowed dramatically 10 min before drawing this sample, it seems reasonable to estimate that the patient's hemoglobin was close to 1.3 g/dl (or less) for at least 30 min. The pH, partial pressure of arterial carbon dioxide (PaCO₂), partial pressure or arterial oxygen (PaO₂), and HCO₃⁻ of the first arterial blood sample were 7.48, 25 mmHg, 411 mmHg, and 22 mmHg respectively, and 40 min later were 7.28, 26 mmHg, 418 mmHg, and 13 mmHg.

During the 1-h of extensive blood loss the isoflurane end-tidal concentration was 0.2% and the oxygen saturation measured by pulse oximetry (SpO₂) remained above 95%. Significant ST depression and frequent premature ventricular contractions were evident for at least the 30 min the hemoglobin was estimated to be 1.3 g/dl.

Anesthesiology, V 90, No 6, Jun 1999
Esophageal temperature was 35°C at the start of the hemorrhage, decreased to a low of 35.5°C 75 min later, and then gradually increased to 34.3°C at the end of the operation (figure 1). With further blood transfusions the hemoglobin concentration was 11.5 g/dl at admission to the recovery room and a forced-air warming blanket was applied. Normothermia was achieved after 2 h. The patient was then extubated and responded appropriately to verbal commands. All postoperative electrocardiograms and myocardial enzyme determinations were unremarkable. Likewise, the neurologic examination and the electroencephalogram in the intensive care unit were normal. The patient was discharged from the hospital on postoperative day 9 without any sequelae.

Similar to our case, Zollinger et al. reported a successful outcome in a 58-yr-old man anesthetized with propofol, fentanyl, and pancuronium who had massive, acute blood loss during debulking of a metastatic renal cell tumor of the lumbar spine, resulting in a hemoglobin of 1.1 g/dl for approximately 30 min, ST segment depression (but no dysrhythmias), transient metabolic acidosis and low mean arterial pressures (range, 50–60 mmHg) despite dopamine and a CVP of 15 mmHg. The frequent premature ventricular contractions noted in our patient may have been caused by her lower arterial pressures (systolic, 65–70 mmHg) causing even greater reductions in oxygen delivery than occurred in the Zollinger et al. patient during the period of severe anemia. Nevertheless, both patients maintained PaO<sub>2</sub> > 200 mmHg and had negative postoperative tests for myocardial and neurologic injury. Zollinger et al. noted only parenthetically that their patient had intraoperative mild hypothermia with temperatures ranging from 33.9°C to 35.9°C during the 30–45 min of severe anemia.

Another case report that associates mild hypothermia with a successful outcome after severe anemia describes a 27-yr-old Jehovah’s Witness who became unconscious and hypotensive after his hematocrit decreased to 6.6% shortly after admission to the intensive care unit after repair of a bleeding duodenal ulcer. He was then intentionally cooled to 34–35°C after sedation with morphine and phenobarbital, paralysis with pancuronium, tracheal intubation, and mechanical ventilation. The above measures plus administration of crystalloid and dopamine were discontinued after 9 days when the hematocrit reached 10%. During this 9-day course of therapy cardiac index and PaO<sub>2</sub> remained above 61·min<sup>-1</sup>·m<sup>-2</sup> and 200 mmHg, respectively.

Although mild hypothermia was a common denominator for the duration of the extremely low hemoglobin concentration in the aforementioned three patients, vasoconstrictors-inotropes, muscle paralysis, mechanical ventilation, anesthetic-induced central nervous depression, and PaO<sub>2</sub> > 200 mmHg were other important common factors that could have likewise contributed to the ability of each patient to survive such severe anemia. Despite the purported benefits of mild hypothermia during ischemia, the limited information available and the presence of other beneficial factors does not permit a reliable delineation of its relative contribution to our patient’s successful outcome. Our case, however, does provide evidence that an anesthetized patient older than 60 yr can survive without adverse sequelae at least 30 min of extremely low hemoglobin levels if aggressive non-blood fluid administration and other resuscitative measures are undertaken to support blood pressure, avoid cardiac arrest, maintain PaO<sub>2</sub> > 200 mmHg, and promote decreases in oxygen consumption and increases in tolerance to myocardial and central nervous system ischemia.

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