Cardiovascular depression from halothane overdose is a well-described cause of cardiac arrest in children undergoing anesthesia. In Salem et al.'s (1) report of cardiac arrests in infants and children, seven of 73 were related to overdose of halothane. In Keenan and Boyan's (2) landmark article on cardiac arrest due to anesthesia, five of six pediatric arrests were due to halothane excess, with “Cardiac arrest ... preceded by bradycardia in 26 of 27 patients.” (2) Thus, although halothane's primary effect is negative inotropism (3), increasing alveolar concentrations of halothane are classically associated with decreased heart rate (HR), and overdose is typically heralded by bradycardia (4). However, in infants and children where atropine has already been given, halothane overdose can lead to profound hypotension despite a normal to high HR. Electrical HR is maintained by the effects of atropine, but ventricular function is all but abolished: electromechanical dissociation or pulseless electrical activity. Bradycardia in this setting occurs only after some time of low to no myocardial perfusion, and should not be awaited as the heralding sign of distress.

Case Reports

Case 1
A 3250-g, 26-day-old male infant presented for pyloromyotomy. Serum electrolytes were normal after intravenous rehydration, and hematocrit was 40%. Routine monitoring was used. Atropine 0.1 mg intravenously (IV) was given with an increase in sinus rate from 140 to 168 bpm. The stomach was evacuated, and, with the infant breathing 100% oxygen, anesthesia was induced with thiamylal, 16 mg IV and succinylcholine, 8 mg IV. Cricoid pressure was maintained throughout endotracheal intubation. Halothane was begun with an inspired setting of 2.5%. The blood pressure (BP) monitor, cycling automatically every 2 min, alarmed indicating hypotension. Halothane was discontinued, and ventilation with 100% oxygen was resumed. Despite a sinus rate of 160 bpm, the infant was pale, and heart sounds were inaudible. Pulses were absent despite a HR on electrocardiogram (ECG) that remained in the 156- to 160-bpm range. Cardiopulmonary resuscitation (CPR) was begun, and 10 μg of epinephrine was given IV. Approximately 30 s after epinephrine, HR increased from its lowest point of 152 bpm to 190 bpm, and BP increased to 96/56 mm Hg. Peak HR was 198 bpm, and maximum BP was 110/70 mm Hg. In view of the brief duration of hypotension, the surgical procedure was pursued, and further perioperative course was uneventful. Postoperative evaluation revealed an active, healthy infant.

Case 2
A 6.8-kg, 7-mo-old female infant presented for strabismus surgery. After uneventful induction of sleep with rectal methohexital 200 mg, the child was carried to the operating room where the usual monitors were placed. Vital signs were normal, and incremental halothane (maximum dialed concentration 3.5%) was administered via mask with high-flow N₂O and O₂. Atropine 0.1 mg was given IV, with prompt increase in HR from 110 to 140 bpm. Endotracheal intubation was easily accomplished without neuromuscular block. Despite HR on ECG of 130 to 137 bpm over the next 2 min, the plethysmographic display of the pulse oximeter was lost. The oximeter probe was repositioned and then replaced, and the supervising anesthesiologist was recalled to the room. The infant was pale, and heart sounds were inaudible. BP could not be obtained. CPR was initiated and epinephrine 20 μg IV was given. The BP was 101/60, 142/80, and 117/70 mm Hg on the next three measurements, all obtained in approximately 1 min. HR was 175 to 180 bpm with good heart tones and peripheral perfusion. Surgery was canceled, and the patient was taken to the postanesthesia care unit. The child made an uneventful recovery and was discharged after 2 h of observation. She has returned twice for uneventful anesthesia and surgery.

Case 3
An 11-wk-old, 4.5-kg infant born at 32 wk postconceptional age presented for inguinal herniorrhaphy. His
be pale, and halothane was decreased to 1.5% and ANESTH ANALG
patient was thriving and without apparent ill effects. The remainder of the perioperative course was un-
epinephrine, the infant was breathing and moving spontaneously. In view of the brief duration of hypo-
tension, it was elected to continue with the procedure. Precordial auscultation could not detect heart
sounds, and HR began to decrease. CPR was begun and epinephrine 20 µg IV was given, CPR being dis-
continued in approximately 30 s as peripheral pulses and precordial heart sounds returned. HR increased
from a nadir of 84 bpm to 146 bpm, and the BP increased to 104/78 mm Hg. Within 1 min of receiving
epinephrine, the infant was breathing and moving spontaneously. In view of the brief duration of hypo-
tension, it was elected to continue with the procedure. The remainder of the perioperative course was un-
eventful. On discharge and at 1 mo followup, the patient was thriving and without apparent ill effects.

Discussion

These three cases demonstrate that halothane can cause severe myocardial impairment with no appre-
ciable change in electrical HR, at least after atropine has been given. This point, while familiar to most pediatric anesthesiologists, is not widely appreciated and is often neglected in the education of residents in anesthesiology. Many practitioners believe that once atropine has been given, halothane's negative effects on the heart are reversed, regardless of concentration of halothane used. The works of Barash and/or Murray are often cited to support this position, and some protection of cardiac output can be provided by atropine (5). Nonetheless, Barash et al. (5), Murray et al. (6,7), and Horigome et al. (8) have all reported that although atropine increases HR the intrinsic myocardial depression caused by halothane is not reversed. Pretreatment with atropine is useful for a variety of reasons but, as in these cases, it may obscure the warning sign of bradycardia, which heralds halothane overdose. HR may be preserved by atropine until, as in Case 3, the period of pulseless electrical activity had lasted for 60 to 90 s. Such cases should not wait until bradycardia occurs.

These events could possibly have been avoided by more vigilant monitoring. Diminution of heart sounds via precordial stethoscope may reflect myocardial impairment due to halothane. Even without a precordial stethoscope, these cases could be detected by alert physical examination. All three children were pale with poor perfusion and absent pulses. Yet in Case 2, when pulse oximeter perfusion was lost, the probe was moved, and replaced, and a replacement for the entire oximeter unit was requested before the attending anesthesiologist was recalled to the room! Physical examination then confirmed what the oximeter had already indicated: perfusion was lacking despite adequate HR by ECG.

The negative inotropic effects of halothane are still incompletely understood, particularly in the neonate and infant (9–11), and halothane induction in infants is associated with a high incidence of hypotension (12). Atropine, like halothane, is not always benign. It can maintain HR by blocking vagal bradycardia and can, at least initially, blunt the bradycardia induced by halothane. In some cases, with therapeutic concentrations of halothane, it will also help maintain blood pressure (13). It does not, however, prevent or reverse the negative inotropic effects of halothane. Even minor slowing of HR during halothane induction of anesthesia may be a useful gauge of depth and speed of induction. When atropine is used, this clinical sign is lost, and closer attention must be paid to heart tones, perfusion, and BP.

References