

be proven. There are a number of studies, however, which suggest that improved outcome might well occur. For example, McKay and Noble³ studied critical incidents and found that the oximeter gives the earliest warning of events that increase risk during anesthesia and that arterial desaturation was the commonest critical incident. Coté *et al.*⁴ concluded that pulse oximetry, in contrast to changes in vital signs, provided an early warning of developing hypoxemia in anesthetized children. When Caplan *et al.*⁵ analyzed the ASA Professional Liability Committee's Closed Claims Study, they found that difficulties in the management of the respiratory system were the single most common cause of injury. Furthermore, the reviewers of the files of closed malpractice claims judged that 40% of these mishaps might have been prevented by the combined use of oximetry and capnometry. Oximeters and capnometers should not be dismissed as just "electronic devices." They measure and continuously display the oxygen saturation and end-tidal carbon dioxide of humans with acceptable accuracy.^{6,7} In view of all this, I cannot accept Dr. Bruner's implication that hypoxemia and underventilation are never uniquely and directly related to the cause of anesthetic mortality.

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The pH Adjustment of 2-Chloroprocaine Hastens the Onset of Epidural Analgesia

To the Editor:—Recently, Glosten *et al.* concluded that there was no effect on the onset of epidural anesthesia when using 3% 2CP buffered with sodium bicarbonate.¹ We have pursued this question with the following study.

After approval from the Institutional Review Board and informed consent from 30 ASA 1 or 2 patients in labor, we randomly divided the patients into one of three groups of ten patients. Group I received 2% 2CP, group II received 2CP buffered to a pH of 7.1 with sodium bicarbonate, and group III received 2CP buffered to a pH of 7.7. The solutions were prepared as follows: 2% 2CP: 3.0 mL saline/30 mL 2CP; pH 7.1 2CP: (1.0 mL 8.4% NaHCO₃/2.0 mL saline)/30 mL 2CP; and pH 7.7 2CP: (2.5 mL 8.4% NaHCO₃/0.5 mL saline)/30 mL 2CP. The pH measurements were made with an ABL-30 blood gas analyzer. All of the 2CP solutions were bisulfite free. All epidural needles were inserted at the L3-4 or L2-3 interspaces using the loss-of-resistance technique with air. All epidural catheters were inserted 2-2.5 cm into the epidural space with the patient in a sitting position. Three milliliters of study solution were administered to each labor patient through the epidural catheter followed by a waiting period of 2 min. At the end of the 2-min period, if the patient had not exhibited signs of an intravascular or subarachnoid injection and if attempts to aspirate blood or cerebrospinal fluid were negative, 5 ml of study solution were administered for a total volume of 8 ml. In order to standardize the time of onset of analgesia, the posterior bilateral S2-3 dermatomes were tested for analgesia to pinprick by a blinded observer at time 0, which was time immediately after the initial 3 ml was ad-

ministered, and every 30 s thereafter until each patient reported loss of pain sensation to pinprick bilaterally. Statistical analysis was done using the one-way analysis of variance and the Tukey and Duncan's multiple range tests. The group receiving 2CP buffered to a pH of 7.7 had a statistically significant faster onset (table 1). At a pH of 7.7, the nonionized fraction of 2CP is 0.001%; at 7.1, it is 1.6%; and at a pH of 7.7, it is 5.9%. The faster onset in the 7.7 pH-adjusted group was probably a result of the increased nonionized portion of 2CP. Dr. Glosten *et al.* may have noticed a quicker onset of the 3% 2CP had they buffered the 2CP from a mean pH of 7.08 to a pH of 7.7. Although the onset of analgesia in the patients receiving the pH-adjusted 2CP was decreased by just slightly more than 60 s, this decreased time of onset may be clinically important in emergent situations where one needs to hasten the onset of analgesia (*i.e.*, imminent delivery, emergency forceps extraction, etc.). In these instances, increasing the pH to 7.7 may benefit both mother and fetus.

TABLE 1. Study Characteristics (Mean \pm SD)

Parameter	Group I	Group II	Group III
pH	4.351 \pm 0.13	7.134 \pm 0.03	7.72 \pm 0.04
Onset (min)	4.00 \pm 1.16	4.45 \pm 0.77	2.65 \pm 0.85*

Values are means \pm SD.

* $P < 0.05$.

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A Complication Associated with the Use of Midazolam

To the Editor:—We wish to draw attention to an unusual complication apparently associated with the use of intravenous midazolam. A 27-yr-old oriental female required urgent anesthesia for evacuation of retained products of conception following spontaneous delivery of a nonviable 20-week fetus. Prior to anesthesia, the patient was alert, there was no active bleeding, and cardiovascular signs were stable and within normal limits. A spinal anesthetic was performed at the L3-4 interspace with the patient sitting; lidocaine 50 mg in 8.5% dextrose was administered. Five minutes after placing the patient supine, a T-10 block was documented. Midazolam, 1 mg iv, was administered for sedation, followed 5 min later at the commencement of the procedure by an additional 1 mg. Immediately following the second dose, the patient complained of burning at the site of injection, and within minutes experienced a tonic-clonic seizure lasting 1-2 min. This was managed successfully with ventilation *via* mask with 100% oxygen. The patient regained consciousness shortly after termination of seizure activity, and showed no evidence of cardiovascular, respiratory, or central nervous system abnormality. Her postanesthetic recovery progressed normally and the remainder of her hospital stay was unremarkable. Although there was no history of any neurologic problem, a postoperative neurology consult and electroencephalogram were planned. However, the patient failed to report for follow-up. In view

of her prior state of good health, the uncomplicated nature of the anesthetic, and the temporal relationship of the seizure to the administration of midazolam, we believe that this complication may have been drug related. Communication with Roche (the drug manufacturer) revealed that a number of other cases of convulsions associated with the use of midazolam have been reported. It is unclear why midazolam, a drug that might be expected to exhibit anticonvulsant activity, should have this effect. We encourage further reports of similar experiences with this agent.

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A Postoperative Pain Management Service

To the Editor:—We would like to comment on the recent exchange of letters discussing the safety of administering epidural opiates outside the Intensive Care Unit.^{1,2}

When we first began using epidural opiates for postoperative analgesia, we too were very concerned about the potential risks of delayed respiratory arrest. Between 1983 and 1986, surgical patients receiving epidural opiates were routinely cared for only in our Intensive Care Units. During that 4-yr period, there was no instance of apnea associated with this therapy. Therefore, as a trial, for 1 yr these patients recovered from surgery on a single selected surgical ward staffed by specially trained nurses. No patient suffered significant delayed respiratory depression, and, therefore, starting in January, 1988, patients receiving epidural opiates have been allowed on all surgical wards at Stanford University Medical Center. During this period, our Acute Pain Service has prospectively followed more than 500 of these patients and have

not reported a single episode of apnea. Hypoventilation, as evidenced by carbon dioxide retention, although infrequent, does occur. In our patient population, it is always associated with sedation. Like the Seattle group, we have found that apnea monitors are of little value in detecting gradual development of hypercapnia. Because of their insensitivity and high incidence of false alarms, we have discontinued using apnea monitors for otherwise low-risk patients.

Potential risk factors for delayed respiratory depression must be recognized.³ In this context, several important points must be emphasized.

First, in our opinion, there is no role for epidural morphine when a catheter has been inserted. The single advantage of morphine over the safer, more lipid soluble opiates is its longer duration of action. However, if intermittent bolus or continuous epidural infusion of drug is offered, agents such as fentanyl or hydromorphone should be used.