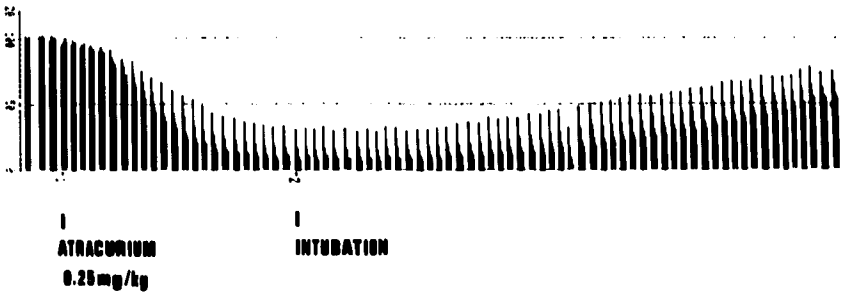

FIG. 1. Electromyographic (EMG) response following atracurium 0.25 mg · kg^{-1}. Seventy-five per cent neuromuscular blockade was achieved after 7 min, when the trachea was intubated.

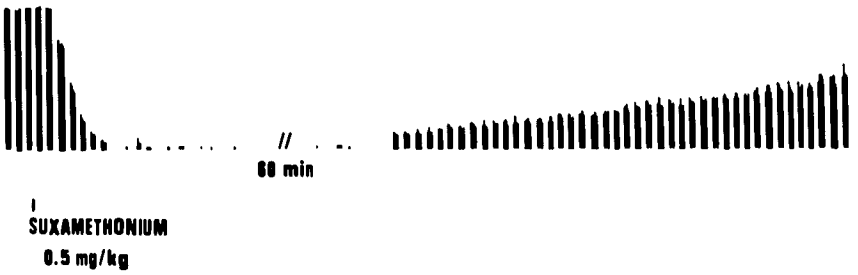

FIG. 2. EMG tracing showing the neuromuscular blockade achieved by succinylcholine 0.5 mg · kg^{-1}. Complete neuromuscular blockade was achieved within 120 s and lasted for 60 min, to be followed by a slow recovery. The blockade was depolarizing in nature during both the onset and recovery periods; the T_4/T_1 ratio ranged between 90–98%.

normal, suggesting that the elimination of atracurium is independent of the plasma cholinesterase activity.

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Mishaps with Patient-controlled Analgesia

PAUL F. WHITE, PH.D., M.D.*

Improved methods for providing postoperative analgesia have led to renewed interest in patient-controlled analgesia (PCA).[1] With this system, the patient is allowed to self-administer small iv bolus doses of a narcotic analgesic using a special programmable infusion pump. Although experience with these devices has become widespread in the United States and abroad over the last 2 years, there have been no reported cases of respiratory arrest in patients receiving PCA therapy. We describe two cases in which healthy, postoperative patients experienced profound respiratory depression as a result of narcotic analgesic overdose secondary to operator errors.

* Associate Professor of Anesthesia, and Chief, Outpatient Anesthesia Service.

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Address reprint requests to Dr. White.

Key words: Equipment: patient-controlled analgesia. Ventilation: depression.

REPORT OF TWO CASES

Patient 1. A healthy 72-yr-old woman (76 kg) underwent a right total hip replacement under general anesthesia. Following an uneventful

TABLE 1. Summary of Problems that Can Occur during Patient-controlled Analgesia (PCA) Therapy

Operator errors
Misprogramming PCA device
Failure to clamp or unclamp tubing
Improperly loading syringe or cartridge
Inability to respond to safety alarms
Misplacing PCA pump key
Patient errors
Failure to understand PCA therapy
Misunderstanding PCA pump device
Intentional analgesic abuse
Mechanical problems
Failure to deliver on demand
Cracked drug vials or syringes
Defective one-way valve at "Y" connector
Faulty alarm system
Malfunctions (*e.g.*, lock)

recovery, a Harvard® PCA syringe pump (C.R. Bard, Inc., Murray Hill, NJ) was connected to an iv catheter with a one-way valve. The valve, located at the junction connecting the tubing from the syringe pump to the patient's regular iv infusion set, prevents narcotic from refluxing into the patient's iv tubing if the catheter becomes occluded. The syringe contained meperidine, 10 mg/ml, and the physician ordered an initial bolus dose of 10 mg with a minimum delay (or lockout) interval of 10 min between successive doses. The device was initially programmed to deliver 1 ml (10 mg) at a delay interval of 10 min. The patient used the device on two occasions while in the recovery room, achieving analgesia without any clinical evidence of excessive respiratory depression. The PCA device was accidentally turned off while the patient was being transferred from the recovery room to the ward.

On arrival in her room, the PCA device was reprogrammed by a ward nurse. She mistakenly programmed the device to deliver a bolus dose equal to 10 ml at a delay interval of 10 min. Twenty minutes after receiving her first self-administered dose on the ward (100 mg), the patient was noted to be extremely somnolent and had a respiratory rate of 3–6 breaths/min. She was given oxygen to breathe and naloxone, 0.2 mg iv, with an immediate reversal of the adverse narcotic side effects. The patient did not require an additional dose of meperidine for 3 h. The programming error was recognized, and the device was reprogrammed to deliver 1 ml (10 mg). The patient continued to use the device for an additional 72 h, self-administering an average meperidine dose of 286 mg/day (12 mg/h) without any untoward sequelae.

Patient 2. A second case involved a healthy, 36-yr-old woman (64 kg) who underwent a cesarean section under epidural anesthesia without any problems. The patient was given sufentanil 50 μg, epidurally, for postoperative analgesia and remained comfortable and pain free for approximately 4½ h. At that time, she was allowed to self-administer narcotic analgesic medication using the Life Care® PCA infuser (Abbott Laboratories, North Chicago, IL). The patient was given sufentanil (5 μg/ml) at an initial dose of 1 ml (5 μg) with a lockout interval of 5 min. The magnitude and duration of analgesia were inadequate to meet the patient's needs; therefore, the dose was increased to 2 ml (10 μg) at a lockout interval of 10 min. During the 14 h she was using PCA therapy, she received a total sufentanil dose of 135 μg (9.6 μg/h).

Late in the evening of the first postoperative day, an alarm sounded, indicating that the drug syringe (cartridge) was nearly empty. The nurse on duty was called to change the cartridge and in the process an accidental bolus dose of sufentanil was administered (she neglected to cross-clamp the tubing connecting the sufentanil cartridge to the intravenous catheter). Within 1–2 min the patient became apneic, cyanotic, and experienced what was described by the staff nurse as "seizure-like" motor activity. However, this may also have been a manifestation of narcotic-induced motor activity (*e.g.*, rigidity). The patient was given oxygen to breathe, naloxone 0.8 mg iv, and diazepam 10 mg iv, with prompt restoration of spontaneous respiratory activity.

A blood sample was obtained 3–6 min after the accidental narcotic injection for determination of the serum sufentanil concentration using a standard radioimmunoassay technique. Although the nurse thought that only 3–5 ml (15–25 μg) had been inadvertently injected, the sufentanil cartridge was found to contain only 20–22 ml immediately after the incident (a full cartridge contains 30 ml). At that time, the nurse stated that some of the drug-containing solution was wasted in the set-up (priming) procedure. However, the measured serum sufentanil level of 0.95 ng/ml would suggest that the patient had received a larger dose. Serum sufentanil levels 5–10 min after a 25–50 μg iv dose of sufentanil range from 0.4 to 0.8 ng/ml.[2] The patient was fully alert and oriented within 15 min and had no recall of the incident. She did not require any additional analgesic medication for almost 3 h. Subsequently, the patient received intramuscular (im) meperidine injections for pain control.

DISCUSSION

The concept of PCA therapy was introduced in the early 1970s[3–5]; however, recent progress in infusion pump technology has renewed interest in this concept. Early clinical studies have demonstrated that safe and effective postoperative pain relief could be achieved with a variety of commercially available PCA devices (Abbott Life Care PCA™, Bard Harvard PCA™, Graseby Cardiff Palliator™, Pharmacia Prominject™, and Cadd-Pac™).[1,6–8] The risk of clinically significant respiratory depression during PCA therapy has been reported to be extremely low. In a group of postoperative patients who achieved good analgesia with a PCA system, Bennett *et al.*[6] made more than 1,300 recordings of respiratory rate and no patient was noted to have a rate lower than 12 breaths/min. Patients undergoing major operations have maintained normal arterial blood gases in the early postoperative period while receiving PCA therapy.[7,8]

In a recent study involving patients undergoing upper abdominal operations,[9] the PCA-treated group had a larger number of patients with elevated capillary carbon dioxide levels (45–55 mmHg) than those groups receiving either im or epidural narcotics. A few cases of respiratory depression have been reported in postoperative patients during PCA therapy.[8,10] However, administration of excessively large bolus doses of narcotics to elderly or hypovolemic patients was felt to be the major contributing factor in these cases. Although no respiratory arrests have been previously reported during PCA therapy, operator errors can result in severe overdosing of patients, with the attendant risk of clinically significant respiratory depression and apnea.

The most common problems with PCA therapy are related to operator and user errors (table 1). If the nursing staff and patients are properly instructed in the use of the PCA device, these problems are preventable. With PCA

therapy, patients are reportedly able to maintain a near optimal state of analgesia with minimal sedation and few side effects.[11,12] Based on these studies, opiate-related side effects (*e.g.*, nausea, vomiting, constipation) would be expected to occur in about 10% of patients. Comparisons with conventional im therapy have revealed that most patients would prefer PCA.[1,12] However, to achieve optimal results with PCA therapy, both the patient and the staff should understand the basic principles upon which the therapy is based. The potential for overdosing patients can be minimized if small bolus doses are used with a mandatory lockout (delay) interval between successive doses. Postoperative analgesic orders should specify the narcotic analgesic concentration, the dosage range in both mg (or μg) *and* ml, as well as the minimum lockout interval. Finally, special care must be taken to assure that the PCA system is properly set up to avoid potentially life-threatening complications.

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Failure of Double-lumen Endobronchial Tube Placement: Congenital Tracheal Stenosis in an Adult

SHIGEYUKI SAITO, M.D.,* SHUJI DOHI, M.D.,† KEIICHI TAJIMA, M.D.‡

Because of its large diameter and the limited availability of sizes, there may be some adult patients in whom a double-lumen endobronchial tube (DLEBT) is difficult to insert into their trachea and bronchi. A recent report indicates that a patient with an aortic aneurysm can be such a case.[1] We have experienced a similar case in which a dissecting thoracic aneurysm compressed the trachea and left main bronchus so that the placement of DLEBT could be performed only with the aid of a fiberoptic bronchoscope. It is possible that patients with narrowing of the vocal cord, tracheal stenosis resulting from thyroid or/and mediastinal tumor or previous tracheostomy may also present difficulties when a double-lumen tube is used in the airway.[2] In those cases, however, difficulties associated with DLEBT intubation can probably be predicted by routine chest roentgenogram and anticipating the medical and clinical conditions of each patient before anesthesia. Recently, in a patient who needed DLEBT for lung surgery, we were unable to insert a DLEBT into her trachea even though the smallest size was selected. This asymptomatic patient was finally diagnosed as having a congenital tracheal stenosis.

* Assistant Professor.
† Associate Professor.
‡ Junior Resident.

Received from the Department of Anesthesiology, Institute of Clinical Medicine, University of Tsukuba, Sakuramura, Ibaraki 305, Japan. Accepted for publication August 18, 1986.

Address reprint requests to Dr. Saito.

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Report of a Case

A 45-yr-old woman who is a nonsmoker, 160 cm in height, and 59 kg in weight, with adenocarcinoma of the lung was scheduled for right lower lobectomy. Her medical history revealed no respiratory diffi-