doses to 90 per cent depression and recovery times to 10 per cent depression.

Our demonstration that the muscles of the hand are more sensitive to the effects of d-tubocurarine than is respiratory muscle is in keeping with the concept of "respiratory sparing." Inspiratory force is a valuable indicator in assessing recovery from neuromuscular blockade, because unlike spirometric tests, it is not affected by intrinsic pulmonary disease. It is essentially an isometric measurement, much like the test of grip strength, and provides a reproducible comparison of the two muscle groups.

The wide range of sensitivities to dTc reaffirms the concept of using the drug in divided doses while monitoring blockade rather than in predetermined doses by weight. The consistent return of inspiratory force prior to peripheral strength indicates that adequate recovery as observed by conventional ulnar or facial nerve monitors implies good ventilatory muscle recovery as well.

REFERENCES


A Hazard of Double-orifice Epidural Catheters

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The abrupt occurrence of cardiovascular collapse during the course of continuous epidural anesthesia may be subsequent to inadvertent subarachnoid injection of local anesthetic due to the migration of the catheter tip into the subarachnoid space. The following case report and laboratory investigation suggest that, in addition to catheter migration, catheter design and injection pressures are factors in the conversion of epidural anesthesia to subarachnoid anesthesia.

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Received from the Department of Anesthesiology, University of California Medical Center, San Diego, 225 West Dickinson Street, San Diego, California 92103. Accepted for publication October 24, 1977.

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Report of a Case

A 65-year-old Mexican-American woman was admitted for below-the-knee amputation and groin dissection for malignant melanoma of the right heel. She had a history of adult-onset diabetes mellitus controlled with 40 units of NPH insulin subcutaneously per day. Four months prior to admission she had had a left below-the-knee amputation with spinal anesthesia, without difficulty. Preoperative physical examination showed blood pressure 140/90 mm Hg, pulse rate 80/min, weight 48 kg, and height 157 cm, and was otherwise unremarkable. Laboratory data, electrocardiogram and chest x-ray were all within normal limits.

The patient received 25 units of NPH insulin subcutaneously an hour preoperatively, with no other premedication. After her arrival in the operating room, electrocardiogram leads and blood pressure cuff were placed and intravenous infusion of 5 per cent dextrose in lactated Ringer's solution, 150 ml/hr, was started. With the patient in the lateral decubitus position, a Portex® double-orifice (orifices 180 degrees opposed 5 mm and 12 mm from the tip) epidural catheter was introduced 3 cm into the epidural space via a 17-gauge Tuohy needle placed in the L2–3 interspace. There was no flow of blood or

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CSF through the needle or the catheter. After the catheter was secured, the patient was repositioned supine, and aspiration from the catheter was done without result. A 3-ml test dose of 3 per cent 2-chloroprocaine was followed, after a 5-minute delay, by a further 12 ml of drug. After 15 minutes a sensory level (to cold) of T9 was established. The operation proceeded uneventfully for 170 minutes, with an estimated blood loss of 200 ml. During this time the patient received two additional 12-ml injections of 0.375 per cent bupivacaine, each injection being preceded by negative catheter aspiration and a test dose of 3 ml. The first reinjection was given after 75 minutes and the second reinjection at 170 minutes. Moderate difficulty was experienced with the second reinjection. A kink in the catheter was noticed by an assistant, who relieved the obstruction in mid-injection. This resulted in a very rapid injection of the final 5 ml of drug. Within 1 minute, the patient became unresponsive, apneic and asystolic. Cardiopulmonary resuscitation was begun, and coincidentally, 10 ml of clear fluid were aspirated from the catheter and sent for chemical analysis. After 5 minutes of external cardiac compression, positive-pressure ventilation with 100 per cent oxygen via endotracheal tube, and continuous epinephrine infusion, blood pressure had returned to 150/90 torr, pulse rate was 110/min, but the patient remained apneic. Fifty-five minutes after cardiac arrest, the patient began moving her facial muscles, and the pupils were mid position and reactive. Sixty-five minutes after cardiac arrest, the patient was moving her upper extremities and intercostal muscles. Seventy minutes after cardiac arrest the patient was breathing spontaneously, with $P_{aCO_2}$ of 37 torr, tidal volume 375 ml, respiratory rate 16/min and vital capacity of 1.11, and the trachea was extubated. Eighty minutes after cardiac arrest, 5 ml of contrast material were injected via the epidural catheter to clarify tip location. Within 30 minutes of extubation sinus bradycardia rapidly progressed to third-degree atrioventricular block. A transvenous pacemaker was placed. However, the patient's condition became progressively resistant to pacing, and she died 20 hours after cardiac arrest.

**DISCUSSION**

It was our opinion that the cardiovascular collapse was precipitated by subarachnoid injection of drug and subsequent total spinal anesthesia. This was confirmed by chemical analysis of the aspirated fluid, as well as by the X-ray, after injection of contrast material, which had the appearance of a myelogram and was consistent with subarachnoid placement. We are unable to explain the patient's subsequent demise and can only attribute it to possible myocardial ischemia and injury during the period of hypotension and resuscitation. The temporal relationship suggested by the abrupt collapse immediately following the rapidly given 5-ml injection of drug seemed to indicate a relationship between the accelerated rate of injection and the site of the drug deposition. We therefore conducted a series of studies to examine this relationship.

Five anesthesiologists (without being informed of the nature of the study) were requested on two separate occasions to inject, in the same manner as their normal practice in administering epidural anesthesia, 3, 10 and 20 ml of 0.375 per cent bupivacaine through identical epidural catheters, the tips of which were exposed to air. On each occasion the injections were made using 3, 6, 12, and 20 ml syringes. During each injection, pressure at the proximal end of the catheter was measured to establish a range of pressures associated with "normal" injections for the remainder of the study. The mean of all measured values was $700 \pm 110$ (SD) torr. Syringe size and volume of injected drug did *not* influence injection pressure. An attempt was then made to simulate the subarachnoid space using a 500-ml bag of 0.9 per cent saline solution. Removing a sufficient volume to establish a 10 cm H$_2$O vertical hydrostatic pressure differential, a small hole was made in the base of this bag and a Portex double-orifice catheter inserted in one of three positions: 1) distal orifice partially inside the container, proximal orifice free; 2) distal orifice completely inside the container, proximal orifice free outside; 3) distal orifice completely inside the container, proximal orifice partially inside the container. Methylene blue-stained 0.375 per cent bupivacaine was then injected through the catheter and the pressure when the drug appeared inside the "subarachnoid space" recorded. In the first and second catheter positions, the pressures necessary to eject the drug from the distal orifice were always greater than 900 torr (range 900–1100 torr). Prior to achievement of an injection pressure of 900 torr, drug exited from the proximal orifice only. In the third position, catheter aspiration was positive and flow occurred essentially through both orifices simultaneously. Careful observation of the catheter in the first and second catheter positions revealed that prior to catheter injection, the fluid in the bag entered the catheter and flowed retrograde for a short distance (5 cm), but that during drug injection, the fluid–drug interface retreated to midpoint between the two orifices until injection pressure approached 900 torr. At this point, drug began to move through the distal port into the bag (fig. 1).

The clinical implication of the above data is that a
double-orifice catheter can achieve the relationships described in positions 1 and 2 of our study. Thus, such a catheter can eject drug from one or both orifices, depending upon catheter position relative to the dura, injection rate, and pressure. The purpose of catheter aspiration and the test dose of drug is to detect the possibility of subarachnoid placement. That this is not foolproof is illustrated by the case report and confirmed by the experiment. The second negative catheter aspiration was probably due to the kink in the catheter and indicates that epidural catheters should also be inspected prior to each injection.

The potential for variation in sites of drug deposition based on the design of the catheter and on the rate of injection is a definite hazard, and we advocate the use of single-orifice catheters. Should double-orifice catheters be used, the injection rates of the test dose and subsequent doses must be equal to prevent possible recurrence of this problem.

REFERENCE


Blanchly Bite Blok® for Edentulous Patients

ROBERT W. LOEHNING, M.D., PH.D.*

The Blanchly Bite-Blok was developed for protection of teeth and tongue during electroconvulsive therapy. We have also found the mouthpiece useful in edentulous patients. It enables us to fill the cheeks and permit better approximation of the anesthesia mask. Mandibular and maxillary bone resorption in edentulous patients results in indentation of the lips and cheeks, making it difficult to maintain a mask fit. Dilution of inhaled anesthetic mixtures with room air during spontaneous breathing and contamination of the surrounding area with anesthetic vapors occurs with ill-fitting masks.

Any of the commonly used medium and large oral airways can be inserted into the Bite-Blok and then placed inside the lips. Anesthesia head straps improve the mask fit when using the mouthpiece.

The usual precautions of removing the mask at intervals and massaging the compressed tissues of the face should also be done when using the mouthpiece in anesthetized patients.

The Bite-Blok, which comes in only one size, can also be used when resuscitating edentulous patients prior to intubation or when intubation cannot be accomplished.

Note: Dr. Paul Blanchly, Professor of Psychiatry, University of Oregon School of Medicine, inventor of the mouthpiece, was drowned in a boating accident in July 1977. The Blanchly Bite-Blok can be obtained from: Kirkman Laboratories, Inc., 934 N.E. 25th, Portland, Oregon 97208.

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Accepted for publication October 31, 1977.

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0003-3022/78/0500—0364 $00.50 © The American Society of Anesthesiologists, Inc.