palsy was entertained. The postoperative course was uncomplicated except for difficulty with eating, swallowing, and speech, and upper airway obstruction in the supine position. He adjusted well and was discharged five days after operation. Full recovery was expected.

DISCUSSION

Anesthetists should be aware of problems associated with bilateral hypoglossal-nerve palsy following bilateral carotid endarterectomies. Unilateral hypoglossal-nerve palsy, easily detected by ipsilateral deviation of the protruded tongue, causes minimal disability. Bilateral nerve palsy can cause airway obstruction, impairment of speech, and difficulty with eating. Damaged myelinated nerve may regain function no more rapidly than 2 mm per day. If possible, total recovery of unilateral hypoglossal-nerve palsy should be allowed prior to operation on the contralateral carotid artery.

REFERENCES

1. Bateman JE: Trauma to nerves in limbs. Philadelphia, W.B. Saunders, 1962, p 88
2. Beebe HG: Complications in Vascular Surgery. Philadelphia, J.B. Lippincott, 1973
3. Bland JE, Chapman RD, Wylie EJ: Neurologic complications of carotid artery surgery. Ann Surg 171:459–464, 1970
4. Bryant MF: Anatomic considerations in carotid endarterectomy. Surg Clin North Am 54: 1291–1296, 1974
5. Grindal AB, Toole JF: Surgical treatment of carotid and vertebral artery disease. An updating to 1974. Ann Intern Med 81:647–649, 1974
6. Thompson JE, Austin DJ, Patman RD: Carotid endarterectomy for cerebrovascular insufficiency. Ann Surg 172:663–677, 1970

A New Method for Positioning Endotracheal Tubes

DAVID J. CULLEN, M.D.,* RONALD S. NEWBOWER, PH.D.,† MORDECAI GEMER, M.D. PH.D.‡

Endotracheal intubation may be complicated by inadvertent insertion of the tube down to the level of the carina or even into a mainstem bronchus. Three methods are currently used to determine proper tube location: 1) a portable chest x-ray, which is expensive, inconvenient, and frequently not immediately available; 2) rapid inflation and deflation of the cuff with palpation in the suprasternal notch—not useful with low-pressure, large-volume, prestretched cuffs; 3) auscultation for breath sounds—notoriously inaccurate and of no value if the tube is at the carina. Described herein are basic features of a new method that is simple, safe, non-invasive, inexpensive, and should ensure proper tube localization.

METHODS

A sophisticated electromagnetic sensing technique allows detection of a special flexible circumferential foil marker band, approximately 3 mm wide, 25 microns thick, and weighing 50 mg. The band is fused into the endotracheal tube at the proximal cuff–tube junction without increasing the external diameter, narrowing the internal diameter, or changing the inherent properties of the tube (fig. 1). Prototype tubes with this modification were fabricated to our design by Portex Ltd. A simple, hand-held, pocket-sized, battery-powered, electronic detector was developed in our laboratories to sense the proximity of the marker bands.[1] The detection system is based on using a com-

* Associate Professor of Anaesthesia, Harvard Medical School at the Massachusetts General Hospital.

† Associate in Anaesthesia (Bioengineering), Harvard Medical School at the Massachusetts General Hospital.

‡ Research Fellow in Surgery, Harvard Medical School at the Massachusetts General Hospital.

Received from the laboratories of the Department of Anesthesia, Harvard Medical School, and the Department of Surgery at the Massachusetts General Hospital, Boston, Massachusetts 02114. Accepted for publication June 15, 1975. Supported in part by USPHS Grant #GM15904-06 and NIH Special Research Fellowship #5F03GM54228-02.

Address reprint requests to David J. Cullen, M.D., Department of Anesthesia, Massachusetts General Hospital, Boston, Massachusetts 02114.

Downloaded from http://asa2.silverchair.com/anesthesiology/article-pdf/43/5/596/622133/0000542-197511000-00027.pdf by guest on 10 April 2024

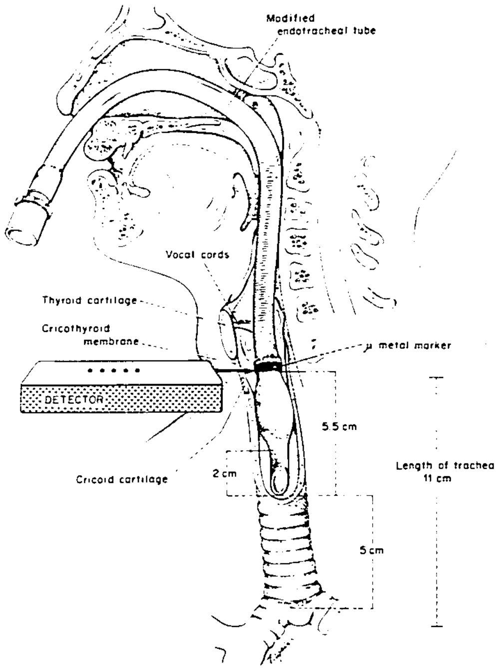

FIG. 1. The electronic metal detector is placed over the skin at the cricothyroid membrane to detect the μ-metal marker of the endotracheal tube. Note that this places the cuff of the endotracheal tube below the vocal cords, while the tip of the tube is approximately 5 cm above the carina in the adult.

mercially available high-permeability alloy (μ-metal) for the foil marker and uses a differential mutual-inductance sensing scheme to measure the distance of this magnetically susceptible band.[2] This approach is relatively insensitive to proximity of extraneous metallic objects and is totally unaffected by intervening conducting fluids and tissue. In addition, it can be accomplished with relatively inexpensive circuitry. The proximity of the marker is displayed on a simple column of light-emitting diodes. A block diagram of the prototype locating device is shown in figure 2. The coils are air-core and hand-wound on a single Bakelite form. Each coil consists of several hundred turns of small-gauge magnet wire, approximately 3 cm in diameter, wound approximately 2 cm apart. The oscillator is constructed from a Signetics 555 integrated circuit. The remainder of the integrated circuits are operational amplifiers. The ladder driver is a special circuit design developed here, but other display devices could be used to obviate it. The entire assembly, including a 9-volt transistor radio battery for power, is housed in a high-impact plastic case. Through careful design, a battery life sufficient for hundreds of uses was obtained. A momentary contact switch bar on the side of the case activates the unit.

After bench, cadaver, and manikin testing, samples of the specially prepared endotracheal tubes were inserted into five criti-

Downloaded from http://asa2.silverchair.com/anesthesiology/article-pdf/43/5/596/622133/0000542-197511000-00027.pdf by guest on 10 April 2024

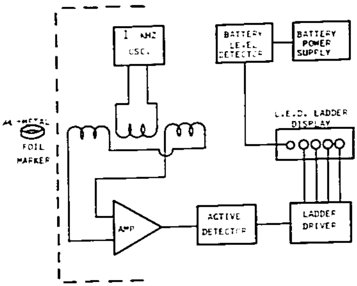

FIG. 2. Block diagram of the prototype endotracheal tube locator. See text for detailed description.

cally ill patients requiring nasotracheal intubation. The metal circumferential foil band was located and positioned at the cricothyroid membrane by using the hand-held detector (fig. 1). The apparent location of the endotracheal marker was then identified on the skin surface with a metal needle placed intracutaneously to allow x-ray confirmation. The location of the circumferential foil band, the surface point (needle), and the endotracheal tube tip were all determined from standard portable AP chest x-rays.

FIG. 3. Portable AP chest film, showing the foil-marked nasotracheal tube in place. Note the position of the needle, which shows how easily the hand-held locator pinpointed the foil marker.

RESULTS (FIGURE 1)

The foil on the tube within the trachea was easily located by the electronic detector and confirmed by chest x-ray (fig. 3). The discrepancies between the location of the metal band determined by the electronic detector (marked on the x-ray by the needle) and that determined directly by the x-ray averaged 0.75 cm and never exceeded 1.3 cm. The tip of the endotracheal tube was 5.1 ± 0.9 cm (1 SE) above the carina.

DISCUSSION

The results show an excellent correlation between the position of the foil band as detected by the electronic detector and that determined directly by x-ray. Furthermore, these data demonstrate that the electronic detector allows one to locate the foil band accurately with respect to external anatomic landmarks in the neck.

The cricothyroid membrane is the most useful reference point in the neck because it is easily identified and very close to skin, facilitating electronic detection of the marker. The distance from the foil band to the tip of the endotracheal tube is 5.5 cm. Since the distance from the cricothyroid membrane to the carina is approximately 11 cm in the adult, a wide margin of safety (about 5.5 cm) prevents the tube from encroaching on the carina or the right mainstem bronchus when the foil band is placed at the cricothyroid membrane level. This margin of safety is appropriate also when the cricothyroid–carina distance shortens during exhalation or hyperextension.[3] Similarly, because the distance from the vocal cords to the cricothyroid membrane is about 1 cm in the adult, the cuff is by definition below the vocal cords when the foil band in the proximal end of the cuff–tube junction is detected at the cricothyroid membrane.

During intubation this method will avoid prolonged carinal stimulation and endobronchial intubation. During anesthesia, when portable x-rays are difficult to obtain, the method will allow the position of the tube to be confirmed with certainty in case it

Downloaded from http://asa2.silverchair.com/anesthesiology/article-pdf/43/5/596/622133/0000542-197511000-00027.pdf by guest on 10 April 2024

has been moved inadvertently. In intensive care units, the need for x-rays to define tube location can be eliminated. To the neophyte laryngoscopist, this endotracheal tube locator method may serve as a teaching device to pinpoint the location of the tube and the potential problems of intubation, in both manikins and adult patients. It will not yield a false reading in the event of esophageal intubation, as the marker will be beyond the range of the detector.

The commercial cost of adding the marker band to a tube should ultimately be only a few cents, and the cost of one detector, if commercially produced (one is probably sufficient for an entire operating suite or intensive care unit) should be less than $100, since the design has already been refined to contain parts that cost less than $15.

We see no physiologic or physical obstacle to this method. It is simple, inexpensive, non-invasive, and assures proper placement of endotracheal tubes.

References

1. Newbower RS: A new aid for positioning endotracheal tubes. Proc Tenth Annual Meeting, Assoc Adv Med Instr, Boston, 1975
2. Newbower RS: Magnetic fluids in the blood. I.E.E.E. Transactions on Magnetics MAG-9: 447–450, 1973
3. Conrardy PA, Goodman LR, Lainge F, et al: Nasotracheal tube mobility with flexion and hyperextension of the neck. Crit Care Med 1:117, 1973

Interaction of the Effects of Hydroxyzine and Pentazocine on Human Respiration

J. Conrad Gasser, M.D.,* and J. Weldon Bellville, M.D.†

Hydroxyzine may enhance the effects of analgesics and therefore reduce the requirements for these drugs. Since pentazocine is a commonly prescribed analgesic and is frequently used together with hydroxyzine, information about their effects and interactions is desirable. Pentazocine has been shown to be a potent respiratory depressant.[1] In a recent study[2] we found that the respiratory depressent effect of hydroxyzine is slight but significant; 75 mg hydroxyzine im was equivalent to 7.5 mg diazepam im in respiratory effect. To study this interaction, the following 2 × 2 factorially designed study was done.

Evaluation of the respiratory effects of the interaction of hydroxyzine and pentazocine was carried out in a single-blind study. The five healthy male subjects, aged 20–30 years, had no known respiratory or other disorder. The drugs and dosages employed were: 1) pentazocine, 30 mg; 2) hydroxyzine, 100 mg; 3) pentazocine, 30 mg, and hydroxyzine, 100 mg; 4) placebo (2 ml saline solution). All medications were given im. At least two days elapsed between test sessions to avoid cumulative effects. The test drugs were administered according to a Latin-square order. The research assistant performing the respiratory test, but not the subject, knew which drug had been administered.

The method of measuring respiratory effects has been used by us in previous studies[3,4] and is a modification of the technique of Eckenhoff *et al.*[5] wherein a subject rebreathes in a closed-circle system and endogenous carbon dioxide is used to stimulate respiration. The outputs of an infrared carbon dioxide analyzer sampling from the level of the subject's lips, pneumotachograph strain gauge, and thermistor were fed into a special-purpose analog computer[6] that plotted end-expiratory carbon dioxide versus alveolar ventilation (BTPS) while the subject rebreathed in the closed system. The use of a similar computer has been described by us.[7] Respiratory depression was measured in terms of displacement of the respiratory response curve. A PDP/8 computer stored the results for each breath and a least mean-square line was fit to it. The intercept at 20 l/m and the slope were printed out. The

* Research fellow.
† Professor.
Received from the Department of Anesthesiology, University of California, Los Angeles, California. Accepted for publication June 17, 1975.
Address reprint requests to J. W. Bellville, M.D., Department of Anesthesiology, UCLA School of Medicine, Los Angeles, California 90024.

Downloaded from http://asa2.silverchair.com/anesthesiology/article-pdf/43/5/596/622133/0000542-197511000-00027.pdf by guest on 10 April 2024