THE USE OF THE CUIRASS RESPIRATOR DURING LARYNGOSCOPY AND BRONCHOSCOPY UNDER GENERAL ANAESTHESIA¹

G. E. SLEATH, M.D., and H. B. GRAVES, M.D.²

LARYNGOSCOPY AND BRONCHOSCOPY are unique in that the operator, by virtue of the procedure itself, interferes with the patient's airway. All anaesthetic methods and techniques are designed to eliminate the anaesthetist and apparatus from the operative field, while at the same time interfering with the patient's airway and ventilation as little as possible.

Local anaesthesia would seem to be a logical method, and is probably more widely used than any other (1, 2). But it is not without danger: overdose and too rapid administration cause many fatalities. Also, with local anaesthesia patients experience a certain amount of discomfort, and the operator does not benefit from the relaxation obtained along with general anaesthesia.

With general anaesthesia most methods have to sacrifice ventilation for relaxation. Some procedures use a partial paralytic technique (2, 3). Others use relaxants and insufflate or ventilate through the side-arm of the bronchoscope (4, 5, 6, 7).

The present paper describes the experiences of the anaesthetic staff of the Vancouver General Hospital with a method that theoretically provides maximum relaxation with maximum ventilation.

METHOD

Toker (8) in 1955 was the first to describe the technique of combining a general anaesthetic of thiopentone sodium and succinylcholine with the use of a KIFA Cuirass respirator for bronchoscopy. A similar technique with a Monaghan respirator was used by Green and Coleman (9), and Bayuk (10) in 1957 commented on the problems met with the use of the technique and the Emmerson respirator.

In our series of cases, the Technicon-Huxley chest-abdomen cuirass respirator was used, not because it was believed superior to other similar models, but because it was the model available (Fig. 1). In this type, negative pressure is applied to the external portion of the body enclosed therein. The cuirass is supplied in four sizes. It is sealed to the body from the upper anterior thorax at the clavicle, curves down beneath the arms, and continues at the lateral rib area in a straight line past the crest of the ilium and completes the seal across the pubic area. The area enclosed is the entire anterior breathing surface of the body, including both the chest and the abdomen. It is constructed of opaque plastic, flexible but practically unbreakable. A soft sponge-rubber gasket is attached to the outer edge of the shell to fill the crevices which might allow leakage.

¹Presented at the Western Regional Meeting of the Canadian Anaesthetists' Society, Calgary, Alta., March 13-15, 1958.

²Department of Anaesthesiology, Vancouver General Hospital and University of British Columbia.

FIGURE 1. The cuirass respirator applied to the patient on the operating table.

At the lower end of the cuirass on each side there is an adjustable supporting leg attached to a plastic ball which rests on the table. These legs are designed to accommodate the height of the abdominal area and also to eliminate pressure of the cuirass on the body with the application of negative or positive pressure.

On applying the cuirass one places the lower end between the crests of the ilium and the pubic crest, allowing the upper end to rest upon, or directly below, the clavicle.

With the larger sized cuirass, it was found that the two legs often slid off the edge of the operating table during the phase of negative pressure, and also that the mattress on the table allowed considerable vertical movement of the legs when the cuirass was operating. It was found convenient to insert under the patient's buttocks a piece of half-inch plywood, measuring six by twenty-four inches, with three-quarter inch holes at intervals along its length, to accommodate the plastic balls on the ends of the legs and thus eliminate the movement.

Pressures may be set anywhere between 0 and 40 cm. of water, both negative and positive, and the respiratory rate may be varied from 12 to 26 per minute.

Preoperative medication consists of meperidine or morphine and hyoscine or atropine in a dosage appropriate to the patient's age and condition.

When the patient arrives in the operating room, his blood pressure is checked and an intravenous infusion of 5 per cent dextrose in water is started, usually in the patient's left arm. The cuirass of suitable size may be placed on the patient at this point, and the straps applied. The supporting legs are adjusted, the ply-

wood board is placed beneath the patient's buttocks, and the plastic balls are located in two convenient holes. The power unit is plugged in and checked, and the hose is connected to the cuirass.

The anaesthetic is commenced with 2½ per cent thiopentone into the intravenous drip. From 200 to 500 mg will be used to produce unconsciousness. A succinylcholine drip,³ with 200 mg per 250 cc. or 500 mg per 500 cc bottle, is begun. The patient is assisted with oxygen by mask from the gas machine until respirations cease. The respirator is then turned on and adjusted to a suitable pressure and rate. The larynx may or may not be sprayed under direct vision with 2 per cent Pontocaine® or 4 per cent Xylocaine® at this stage. The airway is maintained by support of the chin, or by insertion of a rubber airway until the operator is ready to begin. The adequacy of the exchange is checked by placing the mask of the gas machine on the patient's face and noting the amount of movement of the rebreathing bag. It is imperative that the exchange be adequate before the operator begins, and if it is not, the fit of the cuirass, the amount of negative pressure applied, or the ventilating rate must be adjusted until an estimated 400-500 cc. exchange is provided. The succinylcholine drip is regulated to maintain relaxation and apnoea, and intermittent doses of thiopentone are given as necessary. It may be difficult to determine when to use additional thiopentone other than giving it from experience according to the age and build of the patient and the time involved in the operative procedure. An additional guide for more is a marked increase in blood pressure. It is advisable to give oxygen at 500 cc to 1 litre per minute flow by naso-pharyngeal catheter during laryngoscopy, or through the side-arm of the bronchoscope during bronchoscopy.

For these procedures an extra pair of hands greatly facilitates matters. A resident to watch the airway and preserve adequate ventilation of the patient allows time for careful adjustment of the respirator.

During the endoscopy the co-operation of the operator is necessary. We believe the procedure should not be unduly prolonged, especially if it is being done in semi- or total darkness. There is perhaps a tendency on the part of the operator to make unnecessary explorations and demonstrations, encouraged by the ideal working conditions and seemingly simple anaesthetic technique.

When the procedure is completed, the succinylcholine drip is discontinued, and the respirator stopped. The mask from the gas machine is applied to the patient's face and oxygenation is maintained until spontaneous respiration is adequate.

RESULTS

From the middle of 1955 to date, this technique has been used in two hundred cases at the Vancouver General Hospital. At the present time it is used routinely for all individuals that can be fitted with a cuirass, that is, for patients down to about ten to twelve years of age. From Table I, it can be seen that most are adults from thirty to seventy years of age. In the older age groups laryngoscopy for suspected carcinoma is the common procedure, with or without biopsy.

³Anectine (Burroughs Wellcome)

Almost three times as many laryngoscopies as bronchoscopies appear in this series, for many bronchoscopies are still done under local anaesthesia (Table II).

About 75 per cent of the procedures are of relatively short duration, lasting under one-half hour. Only two cases in the series extended over one hour (Table III)

TABLE I
NUMBER OF CASES ACCORDING TO AGE GROUPS

Age (years)	Number
0 - 16	10
16 - 30	12
30 - 40	39
40 - 50	36
50 - 60	49
60 - 70	39
70 - 80	15

TABLE II
NUMBER OF CASES ACCORDING TO PROCEDURES

Procedure	Number
Laryngoscopy	64
Laryngoscopy and Biopsy	63
Laryngoscopy and Polypectomy	21
Bronchoscopy	52

TABLE III
NUMBER OF CASES ACCORDING TO ANAESTHETIC TIMES

Time (minutes)	Number
0 - 30	146
30 - 60	52
60 +	2

Intubation was resorted to for six of the patients in this series. In three, intubation was performed for a tracheotomy at the end of the laryngoscopy. In one, intubation was carried out for biopsy of a large pharyngeal mass following the laryngoscopy. In two patients ventilation was ineffective because of large carcinomatous masses, and intubation was performed to secure a better airway. One of the latter required a tracheotomy forty-eight hours postoperatively.

COMMENTS

In any technique there are advantages and disadvantages, and this one is no exception.

Advantages

Thiopentone and succinylcholine with a cuirass respirator provide a safe, general anaesthetic technique. The combination is non-explosive, eliminating hazards from the breakage of instrument bulbs or from short circuits. Complete

paralysis is provided, eliminating the muscular resistance of the patient's jaw and neck. Paralysis and abduction of the vocal cords facilitates instrumentation and the performance of biopsies and removal of tumors. Adequate oxygenation and removal of carbon dioxide is ensured. Collier and Affeldt (11) have shown in patients totally paralysed from chronic poliomyelitis that at -28 cm of water the chest-abdomen cuirass would provide sufficient reserve as calculated as one standard deviation above the theoretical tidal volume. Kelleher *et al* (12) found that the Monaghan and KIFA cuirass respirators provided 300 to 500 cc tidal volume in paralysed poliomyelitis patients if 15 cm of water negative pressure was used. It has been shown by arterial plasma carbon dioxide determinations that tidal volumes of 250 to 400 cc, with a minute volume of 8 litres provided adequate alveolar ventilation (13). We have felt that we could produce adequate ventilation using pressure varying from 12 to 22 cm water. However, this was only a clinical impression, as no measures of tidal volume or blood oxygen and carbon dioxide levels were taken.

Recovery from the procedure is rapid, providing early return of protective reflexes. At no time after the endoscopy is commenced, need the anaesthetist enter the operative field. The equipment does not encroach into the region of the head and neck, and the cuirass on the chest should not interfere with the manipulation in any way.

Disadvantages

The disadvantages are relative, and are common to most mechanical devices.

First, it is often difficult to get a good fit with the cuirass. Any leak around the shell interferes with the ventilatory efficiency. In very obese patients, fat may be drawn up into the cuirass, filling it almost entirely, and thus leaving no room for the motion of abdominal contents, diaphragm and chest cage.

Adequate ventilation in emphysematous patients is often difficult to obtain. The positive phase of the cycle available with the machine does not seem to improve the situation clinically.

The use of the respirator involves the extra labour of setting it up, and the fitting of the cuirass. It might alarm some patients to have the shell placed on them before they were asleep. Additionally, of course, there is the initial expense of the respirator.

In our series of cases a most constant finding was an elevation of blood pressure, and occasionally of the pulse, during the procedure. Any of four factors may be involved in this pressure rise.

(a) If the exchange is inadequate for any reason, carbon dioxide build-up would occur.

(b) Succinylcholine itself may produce a pressure rise, probably as a result of sympathetic ganglionic stimulation.

(c) Instrumentation of the larynx under light anaesthesia may produce a marked vasopressor response. King *et al*. (14) found an average elevation of 53 mm. mercury systolic and 34 mm. mercury diastolic rise in forty-six patients during intubation with thiopentone and curariform drugs. These pressor responses occurred also in patients who were conscious and intubated awake (15),

but were less prominent if instrumentation was performed in deeper planes of anaesthesia.

(d) If topical anaesthesia is used, a rise in pressure and pulse rate may occur, presumably owing to the action of the systemically absorbed anaesthetic agent upon the cardiovascular system (15). This vasopressor response was not found subsequently to be detrimental to any patient, but did cause some concern at the time of the procedure.

Bradycardia and pulse irregularities did not appear unless the patient had become obviously hypoxic from interference with the airway or from ineffective use of the respirator.

Severe muscular pain, especially of the pectorals and jaw was complained of postoperatively by a few patients. It is believed that this is due to giving the succinylcholine too rapidly.

SUMMARY

A method of performing laryngoscopies and bronchoscopies with thiopentone, succinylcholine and a cuirass respirator is described. Our experiences with two hundred cases are summarized. Some advantages and disadvantages of the technique are outlined.

RÉSUMÉ

Avec presque toutes les méthodes d'anesthésie générale employées pour les laryngoscopies et les bronchoscopies, il faut sacrifier la ventilation en faveur du relâchement musculaire. Dans ces circonstances, théoriquement, l'emploi du respirateur à cuirasse pourrait procurer à la fois une ventilation maxima et un relâchement musculaire maximum. Depuis la dernière moitié de l'année 1955, au cours de 200 cas de bronchoscopies et de laryngoscopies, les auteurs ont employé le respirateur cuirasse, thorax-abdomen, Technicon-Huxley.

On a donné comme prémédication de la meperidine ou de la morphine et de l'hyoscine ou de l'atropine à des dosages appropriés. A l'arrivée à la salle d'opération, on a installé une solution de 5% de dextrose dans une veine et on a ajusté une cuirasse de grandeur convenable en ayant soin de placer l'extrémité inférieure de cette cuirasse sur une planche de bois laminé placée sous les fesses du malade afin d'éviter un mouvement vertical. On a commencé l'anesthésie en injectant dans la tubulure du sérum du thiopentone à 2½%, on en a employé de 200 à 500 mg pour maintenir un état d'inconscience. Puis, on a commencé une goutte à goutte de succinylcholine (1 mg/ml) en assistant la respiration du malade avec de l'oxygène amené par la machine à anesthésie et, cela, jusqu'à ce que la respiration cesse. Alors on a mis le respirateur en fonctionnement et on l'a ajusté à un rythme et à une pression convenables. A ce moment, il est facultatif d'arroser le larynx soit avec de la Pontocaine® à 2% ou de la Xylocaine® à 4%. Les voies respiratoires sont maintenues libres en supportant le menton du malade et en plaçant un tube pharyngé en attendant que le chirurgien soit prêt à procéder; on peut contrôler l'efficacité des échanges respiratoires en plaçant le masque de la machine à anesthésie sur la figure du malade et en notant le

nombre et l'amplitude des mouvements du ballon. Le respirateur doit produire des échanges de 400 à 500 ml.

On provoque l'apnée et le relâchement musculaire par le goutte à goutte de succinylcholine et l'inconscience par des doses intermittentes de thiopentone. Pour la laryngoscopie, on donne de l'oxygène par des catheters nasaux et pour la bronchoscopie, on donne l'oxygène par le tube latéral du bronchoscope.

Les avantages de ce procédé sont l'usage d'un mélange non explosif et, tout en donnant un relâchement complet, il maintient une ventilation adéquate. Le réveil est rapide et les réflexes protecteurs réapparaissent précocement.

Chez les emphysemateux, il est souvent difficile de procurer une ventilation adéquate. On peut s'attendre à rencontrer des difficultés, chez certains malades, pour ajuster la cuirasse et, chez les personnes grasses, il peut arriver que la graisse soit aspirée dans la cuirasse et la remplisse complètement.

REFERENCES

1. CHURCHILL-DAVIDSON, H. C. Anaesthesia for Bronchoscopy. *Anaesthesia* 7: 237-242 (1952).
2. Anaesthesia in Broncho-Esophagology. A Panel Discussion. *Trans. Am. Broncho-Esophagological Ass.*, 1955, pp. 50-72.
3. WYANT, G. M., DOBKIN, A. B., & KILDUFF, C. J. Problems of Anaesthesia for Bronchoscopy. *Canad. M. A. J.* 76: 1011-1015 (1957).
4. SHANE, S. M., & ASHMAN, H. A Method of General Anaesthesia for Bronchoscopy and Bronchography. *A. M. A. Arch. Otol.* 62: 319-321 (1955).
5. KOVACS, S. Method of Ventilation during Bronchoscopy. *Anesthesiology* 18: 335-336 (1957).
6. BOONE, G. D. A Technique of Intravenous Pentothal Sodium Succinylcholine Anaesthesia for Bronchoscopy and Bronchography (A Report of 600 Cases). *Ariz. Med.* 13: 352-356 (1956).
7. ALVER, E. C., & LEEK, J. H. Induced Paralysis for Endoscopic Procedures. *A. M. A. Arch. Otol.* 62: 399-405 (1955).
8. TOKER, P. Anaesthesia for Bronchoscopy. Use of Respirator. *South African M. J.* 29: 40-41 (1955).
9. GREEN, R. A., & COLEMAN, D. J. Cuirass Respirator for Endoscopy. *Anaesthesia* 10: 369-373 (1955).
10. BAYUK, A. J. Chest Respirator for Bronchoscopy and Laryngoscopy. *Anesthesiology* 18: 135 (1957).
11. COLLIER, C. R., & AFFELDT, J. E. Ventilatory Efficiency of the Cuirass Respirator in Totally Paralyzed Chronic Polio Patients. *J. Appl. Phys.* 6: 531-538 (1954).
12. KELLEHER, W. H., KINNIER, A. B., RUSSELL, W. R., & STOTT, F. D. Notes on Cuirass Respirators. *Brit. M. J.* 2: 413-415 (1952).
13. PRICE, H. L., CONNOR, E. H., & DRIPPS, R. D. Some Respiratory and Circulatory Effects of Mechanical Respirators. *J. Appl. Phys.* 6: 517-530 (1954).
14. KING, B. D., HARRIS, L. C., GRIEFENSTEIN, F. E., ELDER, J. D., & DRIPPS, R. D. Reflex Circulatory Responses to Direct Laryngoscopy and Tracheal Intubation Performed during Surgical Anesthesia. *Anesthesiology* 12: 556-566 (1951).
15. KING, B. D., ELDER, J. D., PROCTOR, D. F., & DRIPPS, R. D. Reflex Circulatory Responses to Tracheal Intubation Performed under Topical Anesthesia. *Anesthesiology* 15: 231-238 (1954).