A "LAST DITCH" AIRWAY*

JOSEPH A. FISHER†

WHEN FACED WITH APNOEA or respiratory obstruction one must be able to obtain an airway and to provide ventilation within minutes if the patient is to survive. This can usually be accomplished by removing foreign material or blood from the airway and by positioning the head and jaw in such a way as to prevent the soft tissues from falling together.[1] Ventilation can be assisted, if necessary, by applying intermittent positive pressure by mouth or by mask and self-inflating bag. If these manoeuvers do not produce totally satisfactory results, the trachea must be intubated and the lungs ventilated at once.

Occasionally one is confronted with a patient whose trachea cannot be intubated. This may be due to a variety of airway problems which may be the cause of, or totally incidental to, the patient's collapse (Table I). Often the first physician to attend the patient may lack the experience, the skill, or the proper equipment to overcome these obstacles.

The conventional methods for obtaining an airway having failed, the survival of the patient, now more than ever, depends on the *effectiveness* of the next steps. Rigid bronchoscopy is an excellent means of overcoming upper airway soft tissue obstruction. Effective use of this instrument, however, requires considerable practice. The necessary ancillary equipment including light source and suctioning apparatus is seldom available during emergencies. An emergency tracheostomy, even in experienced hands, is a difficult and dangerous procedure. A large variety of percutaneous tracheostomy devices have been described in the literature[2,3] which appear to function adequately in the hands of their inventors. The difficulties and complications faced by others in their use[4,5] and their general lack of availability all but eliminate consideration of their use in such emergencies.

Most physicians are oriented towards inserting one or more large bore needles percutaneously as an emergency airway. These are available up to 14 gauge in most hospitals. Having introduced the needle, the physician is often faced with a number of problems he may not have anticipated. First, it is impossible to breathe through such a small airway.[3,6] Bougas and Cook[7] in human experiments concluded that a 13-gauge needle was inadequate for all but the smallest infants. One can best appreciate the difficulties encountered by occluding the nose and trying to breathe through one or even two 14-gauge needles. The second problem involves assitance with oxgenation and ventilation. A source of low flow oxygen and tubing that would provide a tight connection to one or more needles could provide a continuous stream of oxygen that would easily meet basal adult requirements (129 to 186 ml of oxygen per minute).[8] However, the lack of alveolar ventilation would lead to a relentless rise in Pa_{CO_2}.[9,10] A gas source providing intermittent high pressure jets can force sufficient volumes of gas through even an 18-gauge needle to provide adequate oxygenation and ventilation, assuming gas can escape passively from an unobstructed upper airway.[12,13] But if there is any element of obstruction, this can lead to a precipitous rise in intrathoracic pressure and thus to lung rupture or profound hypotension secondary to decreased venous return to the heart.[10] The required oxygen tanks, ventilators, special tubings and connectors, even if present in the hospital, are seldom available and assembled within the critical time that would allow intratracheal needles to function as adequate emergency airways.

An emergency airway must then be readily available, simply adaptable to provide intermittent positive pressure ventilation and of sufficient bore to allow spontaneous respiration.

Recently there has been widespread use of collapsible bags for the storage of intravenous solutions and the spike which connects the tubing from the intravenous cannula to the collapsible bag no longer requires a venting channel and can thus be made of one large bore. As this intravenous equipment is available or can be quickly brought to a patient who has collapsed, I explored the suitability of this spike as an emergency percutaneous tracheostomy device.

From: The Department of Anaesthesia, Wellesley Hospital and University of Toronto, Toronto, Ontario.

*Presented at the Annual Meeting, Canadian Anaesthetists' Society, May 23, 1978.

†Present address: J.A. Fisher, M.D., Department of Anaesthesia, St. Michael's Hospital, 30 Bond Street, Toronto, Ontario, M5B 1W8.

TABLE I

SOME CONDITIONS POSING DIFFICULTIES WITH INTUBATION

(1) Related to patient's collapse:
- obstruction of airway by
- direct injury
- foreign body
- tumours
- inflammation
- bilateral vocal cord paralysis

(2) Incidental to collapse:
- (a) "buck" teeth, receding mandible, limitation of opening of the mouth
- (b) neck: fixed, fragile or fractured
- (c) congenital conditions such as tissue hyperplasia, dysplasia floppy epiglottis, large teeth to larynx distance

MATERIALS AND METHODS

The most suitable spike comes from the Fenwal Y-type blood-solution recipient set (Code 4C2186) (Figure 1). It has a full circumferential skirt and a tapered point designed to prevent laceration of the blood bag on insertion. Other models have a semicircular skirt and a stronger, thicker point. The length of the spike below the skirt varies from 25 to 39 mm in different models.

Oxygen flow through number 18 and 16 Angiocath catheters, a 3 ml disposable plastic syringe and a spike (blood set model) was measured under various driving pressures monitored with a water manometer. Flow was measured by a volume displacement spirometer recording through mechanical linkage on an electric constant speed drum.

The *in vivo* data were obtained from untrained normal male volunteers, each of whom was seated, wearing a nose clip and breathing for seven minutes through a spike held in his mouth, completedly sealed with his lips. Gas was inhaled from an oxygen-filled volume displacement spirometer and exhaled back into the spirometer through a carbon dioxide absorber.

From tests on adult cadavers,* the following method of insertion was developed. The operator stands at the head of the patient. A rolled towel or similar object is placed between the patient's scapulae to extend the head over it. The cricothyroid space is identified and a stab is made through the skin overlying it with a number 11 scalpel blade, scissors or similar sharp instrument (Figure 2). Then, stabilizing the skin and trachea with one hand, the spike is passed through the skin and then advanced with a sharp, jab-like motion (Figure 3). Often a "pop" is heard as the spike enters the trachea. The bevel of most syringes happens to fit the tubing end of the spike. One can therefore easily ascertain proper positioning by the ability to inject or aspirate air (Figure 4).

*Only adult cadavers were tested. Children were considered unsuitable for this technique due to the small size and softness of their tracheae.

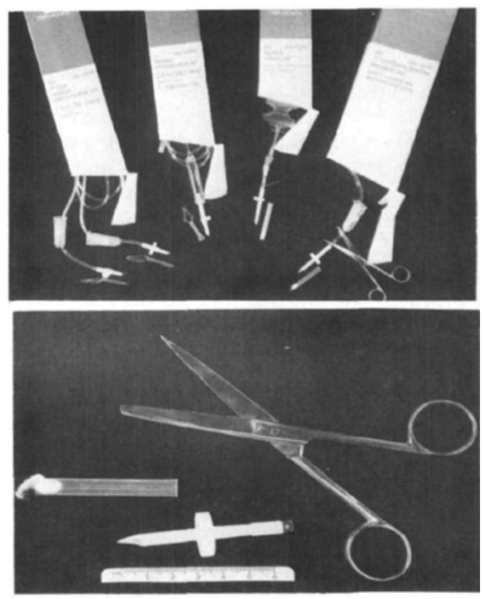

FIGURE 1 (a) A variety of spikes in different intravenous solutions sets. Internal diameter in all is 3 mm and external diameter 5 mm. (b) The spike from a "Y" blood infusion set. Note the complete skirt. The length of the spike below the skirt is 31 mm.

One can now easily exploit a number of fortuitous circumstances to assist ventilation. Re-

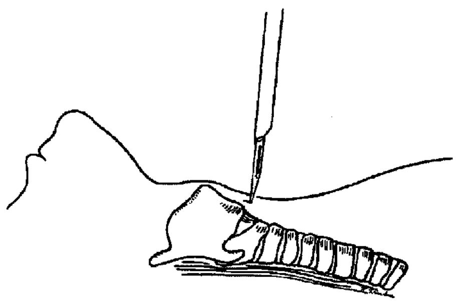

FIGURE 2 With the head extended to stabilize the trachea a cut is made through the skin or through the cricothyroid membrane as well.

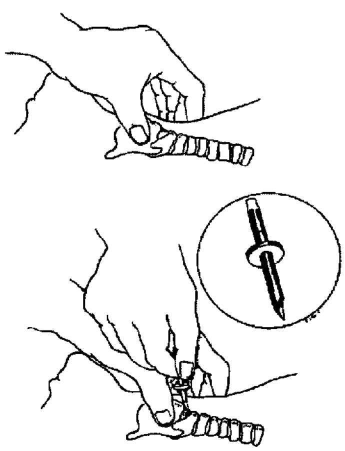

FIGURE 3 One hand stabilizes the trachea while the other applies pressure on the spike along its long axis taking care not to bend over the point.

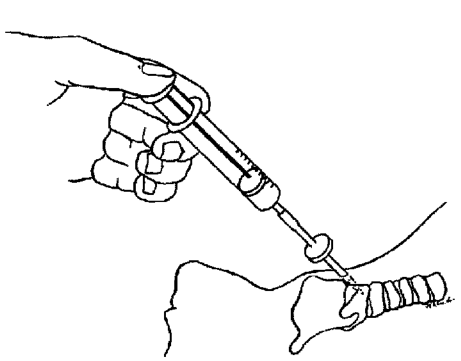

FIGURE 4 The bevel of most standard syringes fits into the proximal end of the spike. The ability to inject or aspirate air assures proper positioning.

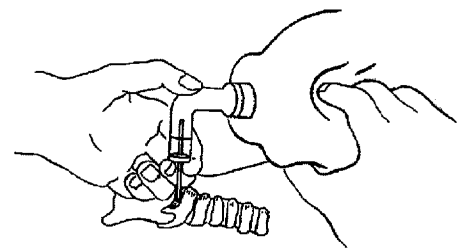

FIGURE 5 By removing the mask and occluding the opening of the "elbow" with the skirt of the spike, pressure from the bag is directly transmitted to the trachea.

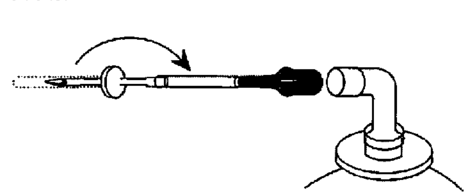

FIGURE 6 The protective tubing fits onto the proximal spike. One can either blow here by mouth or attach on a 5.0 tracheal tube connector and through this effect ventilation by a self-inflating bag or ventilator.

moving the mask from a self-inflating bag allows the open end of the "elbow" to be occluded by the widened "skirt" of the spike (Figure 5). This will allow the positive pressure to be transmitted directly to the trachea. Alternatively one can take the protective tubing from the tip of the spike, and wedge it onto the end of the tubing (Figure 6) to allow application of positive pressure by mouth. This tubing is also of sufficient bore to receive a 5 or 5.5 mm tracheal tube connector. The spike can thus be connected to a self-inflating bag or even to a ventilator.

RESULTS

The pressure flow studies (Figure 7) show the marked advantage of this device over a number 14 intravenous catheter, or even a 3 ml syringe proposed by Stinson[15] as a connector for a needle to a ventilator.

In Figure 8, minute ventilation is plotted against body weight for the male volunteers breathing through the spike held in their mouths. The dotted lines were derived from the Radford nomogram[16] which predicts the minute ventilation for normal males maintaining a Pa_{CO_2} of 5.32 kPa (40 torr) at respiratory rates between 12 and 18 per minute. None of the volunteers re-

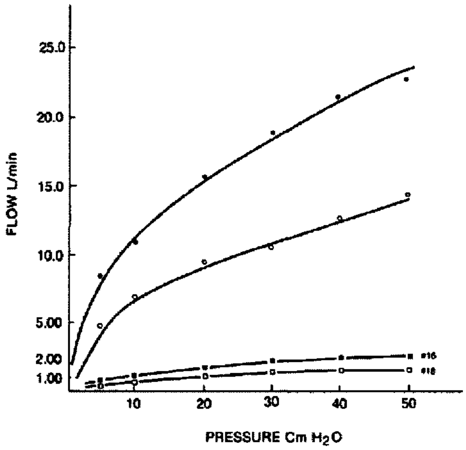

FIGURE 7 Pressure-flow studies comparing intravenous cannulae (squares); 3 ml syringe (open-circles) and a spike from a blood set (closed circles).

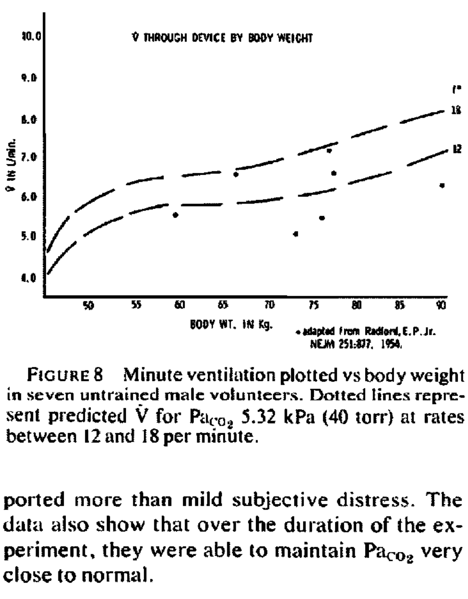

FIGURE 8 Minute ventilation plotted vs body weight in seven untrained male volunteers. Dotted lines represent predicted V̇ for Pa_{CO_2} 5.32 kPa (40 torr) at rates between 12 and 18 per minute.

ported more than mild subjective distress. The data also show that over the duration of the experiment, they were able to maintain Pa_{CO_2} very close to normal.

Discussion

The cricothyroid space is the site of choice for an emergency tracheostomy. It is easily palpated with minimal instruction or knowledge in anatomy, as a hollow between the thyroid cartilage and the prominent cartilage immediately caudad to it, the cricoid. The size of the space in adults averages 0.9 cm × 3.0 cm.[17] With the head extended, the tissues overlying this space are quite thin, even in moderately obese patients. Beneath the skin, there are only cervical fascia, the middle cricothyroid ligament, and internal submucosa and mucosa to penetrate. No major vessels or nerves traverse this space. If the fascial planes have not been entered first by the scalpel blade, the spike point can penetrate these tissues. *The cricoid cartilage is a complete ring and thus* in adults, it allows application of considerable force to penetrate the tissues without causing collapse of the trachea. The posterior extension also protects against accidental posterior perforation. In approaches caudad to the cricoid one must bear in mind underlying glandular structures and appreciate the posterior angulation of the trachea in this region.

Several other points of note were appreciated during the tests on cadavers:

(1) None of the spikes will penetrate the skin even with maximal force. However, pinching up the skin and making a small cut with a nurse's scissors allowed insertion through the rest of the tissues.

(2) The spike model from the blood sets has a thinned curved point which bends easily if pressure is not maintained strictly along the long axis of the spike. The point on the other models was sufficiently tough to withstand pressure in a transverse direction as well as twisting motion on human tissues.

(3) My colleagues who have practiced this on cadavers are surprised at the considerable force required to penetrate the fascial planes if not pre-incised with a scalpel blade or scissors. If the point is not well wedged into the tissue before the force is applied, the spike may slip down either side of the trachea and cause damage to soft tissues.

(4) Blood administration spikes from the Abbott blood Y-Type Set 66 #8966, and Cutter 899-84) (Figure 9) can be used as emergency tracheostomy tubes. Except with the use of the 3 ml syringe described by Stinson[15] they are more difficult to adapt to positive pressure ventilation as their spikes are short (24 and 26 mm respectively) and the spike protectors are in cap form. Cutter model 8190-80 has a dull, weak point and it is likely unsuitable for these purposes."

Summary

In a patient whose airway is in jeopardy after unsuccessful attempts at conservative measures

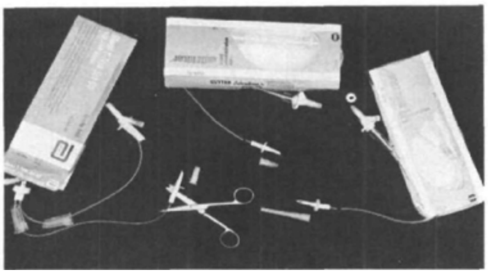

FIGURE 9 Blood administration sets from Abbott (left), and Cutter (center and right). These manufacturers produce double lumen spikes for glass solution containers. Some of their blood administration sets contain single lumen tubes. See text for discussion.

to clear it and after failed attempts at intubation, the intravenous tubing connector spike may be considered as an emergency percutaneous tracheostomy device. It is readily available wherever physicians have intravenous solutions at hand. It is inserted through the cricothyroid space with the help of a scalpel blade or other sharp instrument such as a pair of scissors. A severed spike can be as easily carried in a pocket, purse or medical bag as can an intravenous cannula. A number 11 scalpel blade fits neatly between two credit cards. The shape of the spike makes it fortuitously adaptable to intermittent positive pressure ventilation by mouth or standard resuscitation equipment. If the patient is otherwise well enough, it is of sufficient bore to allow spontaneous respiration. I have been fortunate not to have had the opportunity to use this device in an emergency situation as of the time of the submission of this paper.

RÉSUMÉ

Lorsque dans l'obstruction des voies aériennes supérieures les mesures usuelles de déblocage et les tentatives d'intubation s'avèrent infructueuses, l'embout perforant d'une tubulure d'administration de solutions intraveineuses peut être utilisé comme canule de trachéostomie d'urgence. Cet embout disponible partout où on administre des solutés est inséré à travers la membrane cricothyrodienne après incision avec une lame de bistouri ou tout instrument tranchant comme une paire de ciseaux par exemple. L'embout, une fois séparé de la tubulure se transporte facilement dans les poches, la bourse ou la trousse médicale. Une lame de bistouri No. 11 se glisse bien entre deux cartes de crédit. La forme de l'embout est compatible avec la ventilation positive intermittente soit par la bouche soit par un appareil standard et si l'état du patient le permet, il est de calibre suffisant pour permettre la respiration spontanée.

ACKNOWLEDGEMENTS

I am indebted to Dr. F.R.H. Wrigley, Dr. P.R. Ramachandran, and Dr. Simon Tindal and the Department of Anaesthesia at Wellesley Hospital, Toronto. Their encouragement, advice and the facilities they made available to me made this paper possible. I would like to thank Michael Kovacs for technical assistance, Rasa Skandra for her excellent illustrations and Jocelyne McRoberts for secretarial assistance.

REFERENCES

1. DRIPPS, R.D., EXKENHOFF, J.E., & VANDAM, L.D. Introduction to Anesthesia, 5th ed. W.B. Saunders. p. 127 (1977).
2. TOY, F.J. & WEINSTEIN, J.D. A percutaneous tracheostomy device. Surgery *65*: 384 (1969).
3. RYHE, D.S., WILLIAMS, G.V., & PROUD, G.O. Emergency airway by cricothyroid puncture or tracheostomy. Tr. Am. Acad. Opth. & Otol. (1960).
4. SMITH, V.M. Perforation of trachea during tracheostomy performed with Shelders tracheotome. J.A.M.A. *165*: 2074 (1975).
5. HAMILTON, R.D. Fatal hemorrhage during tracheostomy. J.A.M.A. *174*: 530 (1960).
6. HUGHES, R.K. Needle tracheostomy. Arch. Surg. *93*: 834 (1966).
7. BOUGAS, T.P. & COOK, C.D. Pressure-flow characteristics of needles suggested for transtracheal resuscitation. N.E.J.M. *262*: 511 (1960).
8. NUNN, J.F. Applied respiratory physiology. London, Butterworth & Co., pp. 146–147 (1969).
9. JACOBY, J.J., HAMELHERG, W., ZIEGLER, C.H., FLORY, F.A., & JONES, J.R. Transtracheal resuscitation. J.A.M.A. *162*: 629 (1956).
10. ATTITA, R.R., BATTIT, G.E., & MURPHY, J.D. Transtracheal ventilation. J.A.M.A. *234*: 1152 (1975).
11. JACOBS, H.B. Emergency percutaneous transtracheal catheter and ventilator. The Journal of Trauma *12*: 50 (1972).
12. SPOEREL, W.E., NARAYANAN, P.S., & SINGH, N.P. Transtracheal ventilation, Brit. J. Anaesth. *43*: 932 (1971).
13. SMITH, R.B., SCHAER, W.B., & PFAEFFLE, H. Percutaneous transtracheal ventilation for anaesthesia and resuscitation: a review and report of complications. Can. Anaes. Soc. J. *22*: 607 (1975).
14. CHAKNAVARTY, K., NARAYANAN, P.S., & SPOEREL, W.E. Further studies on transtracheal ventilation: the influence of upper airway obstruc-

tion on the patterns of pressure and volume changes. Brit. J. Anaesth. *45*: 733 (1973).
15. STINSON, T.W. A simple connector for transtracheal ventilation. Anesthesiology *47*: 232 (1977).
16. RADFORD, E.P., FERRIS, B.G., & KRIETE, B.C. Clinical use of a nomogram to estimate proper ventilation during artificial respiration. N.E.J.M. *22*: 251 (1954).
17. CAPAROSA, R.J. & ZAVATSKY, A.R. Practical aspects of the cricothyroid space. Laryngoscope *67*: 577 (1957).