$$P_{C_{CO_2}} = \frac{Pa_{CO_2} - \dot{Q}_s/\dot{Q}_t \times P\bar{v}_{CO_2} + P\bar{v}_{CO_2} - P\bar{v}_{CO_2}}{1 - \dot{Q}_s/\dot{Q}_t}$$

$$= \frac{Pa_{CO_2} + (1 - \dot{Q}_s/\dot{Q}_t)\bar{v}P_{CO_2} - P\bar{v}_{CO_2}}{1 - \dot{Q}_s/\dot{Q}_t}$$

$$= P\bar{v}_{CO_2} - \frac{P\bar{v}_{CO_2} - Pa_{CO_2}}{1 - \dot{Q}_s/\dot{Q}_t} \qquad (3)$$

Substituting this equivalent of Pc_{CO_2} for Pa_{CO_2} in equation (1), this becomes:

$$V_D/V_T = \frac{\left(P\bar{v}_{CO_2} - \frac{P\bar{v}_{CO_2} - Pa_{CO_2}}{1 - \dot{Q}_s/\dot{Q}_t}\right) - P\bar{E}_{CO_2}}{P\bar{v}_{CO_2} - \frac{P\bar{v}_{CO_2} - Pa_{CO_2}}{1 - \dot{Q}_s/\dot{Q}_t}} \qquad (4)$$

Tables 1 and 2 show examples of the effect on V_D/V_T, calculated with equation (4), of different combinations of $P\bar{v}_{CO_2}$, Pa_{CO_2}, $P\bar{E}_{CO_2}$, and $\dot{Q}_s/\dot{Q}_t$. In table 1, $P\bar{v}_{CO_2}$ and Pa_{CO_2} are 45 and 40 mm Hg, respectively, whereas in table 2 these values are 55 and 50. If V_D/V_T is calculated using equation (1), the values shown in the first columns in each table are obtained. The values for each of these ratios decrease progressively as $\dot{Q}_s/\dot{Q}_t$ increases. In each instance, the percentage errors which would result from using equation (1) are shown in parenthesis in the tables and apply only in the examples given. In general, the effect of anatomic shunt on V_D/V_T is proportional to its magnitude; however, increasing V_D/V_T tends to decrease the extent of this effect. In one of the examples shown in table 1, a normal V_D/V_T of 0.31 in the presence of a $\dot{Q}_s/\dot{Q}_t$ of 0.5 would become 0.40 (above the normal range) if equation (1), which ignores the effect of anatomic shunt, were to be used instead of equation (4) to calculate this ratio. This would lead to a misinterpretation of pathophysiology.

Providing the errors of measurement of parameters do not exceed 5 per cent, it is suggested that equation (4) should be used to calculate V_D/V_t when $\dot{Q}_s/\dot{Q}_t$ can be of sufficient magnitude (0.2 or more) to affect this ratio significantly. This is in keeping with the previously-mentioned statement of Rossier *et al.*[3] In clinical situations an increased V_D/V_T is frequently associated with an increased $\dot{Q}_s/\dot{Q}_T$, and under these circumstances its accurate determination is possible only if equation (4) is used.

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An "Immobile Needle" for Nerve Blocks

ALON P. WINNIE, M.D.*

Success with any nerve block depends not only on precise placement of a needle, but also on stabilization of that needle during injection of the anesthetic solution. Movement of the needle in attaching and detaching a syringe may dislodge its tip from the desired nerve or fascial plane and result in incomplete anesthesia. At Cook County Hospital we have developed a simple and inexpensive technique which allows complete immobilization of the needle throughout the entire performance of a nerve block.

A small-bore disposable intravenous extension tubing is interposed between the needle and the syringe containing the anesthetic solution. After the entire system has been filled with anesthetic solution, the extension tubing is clamped off and the needle is

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* Division of Anesthesiology, Cook County Hospital, Chicago, Illinois.

properly placed for the desired nerve-block procedure. Upon obtaining paresthesia or after entering the proper fascial plane, the tubing is unclamped and aspiration is accomplished by an assistant (or with the anesthetist's free hand) without movement of the needle. The anesthetic is then injected. If the syringe must be detached and re-attached, this may be done without moving the needle, because of the flexibility of the extension tubing. Worthy of mention is the fact that if care is not taken to fill the extension tubing completely with anesthetic agent, several ml of air may be injected during performance of the block. This is not a serious occurrence, assuming the injection is not intravascular.

This "immobile needle" has been used in several hundred nerve blocks and has unquestionably enabled us to avoid many failures or partial blocks, particularly in cases where removal of the syringe proved to be mechanically difficult or awkward.

A Minimally Traumatic, Intermittently Inflated Endotracheal Cuff

JOHN I. LAURIA, M.D., AND MURRAY N. ANDERSEN, M.D.

Recent reports have indicated an increasing awareness of the danger of tracheal stenosis resulting from cuffed tracheostomy or endotracheal tubes employed for long-term ventilatory support.[1, 2, 3] In the majority of instances tracheal stenosis appears to be produced by the pressure of the inflated cuff rather than by the tube itself. Despite various attempts to reduce the incidence of this complication, efforts to date have failed to provide a definitive solution to the problem.[4]

It is generally believed that pressure against the tracheal mucosa by the inflated cuff, particularly during periods of hypotension and reduced blood flow, interferes with circulation to the mucosa and underlying soft tissues, resulting in pressure necrosis. The objective of the present study was to devise a simple, functionally-reliable technique which would reduce cuff pressure effects to the lowest level possible. The rationale upon which the method reported is based assumes that such pressure effects would be minimized by: 1) intracuff pressure which is at the lowest level adequate to prevent air leak during the inspiratory phase; 2) reduction of duration of cuff inflation time to a minimum, *i.e.*, inflation during the inspiratory phase only; 3) configuration of the inflated cuff such that deformation of the trachea by the cuff would not be required to produce an adequate air seal.

These requirements appear to have been met by the development of an automatically-inflated cuff system in which intracuff pressure is equal to, and synchronous with, intratracheal pressure (the absolute minimum required to avoid leakage) and whose use requires no additional mechanisms other than a direct connection to the inspiratory air flow delivered by the ventilator. The system's essential features are: 1) a cuff large enough to be inflated sufficiently to produce an adequate air seal without stretching the cuff material; 2) inflation of the cuff by the ventilator airway pressure so that intratracheal and intracuff pressures are equal and the cuff inflation period is synchronous with the inspiratory phase of the ventilator. The latter feature is achieved by connecting the cuff-inflating tubing to a side arm of the ventilator connection to the endotracheal tube (fig. 1).

METHODS

The prototype tubes were constructed with a thin-walled Sanders cuff from which the original inflating tubing was removed and replaced with a firmer, more kink-resistant Air-Lon catheter. Both medium and large cuffs

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Received from the Departments of Anesthesiology and Surgery of the State University of New York at Buffalo and the E. J. Meyer Memorial Hospital, Buffalo, New York. Supported by a Research Grant from the USPHS (GM-15768).