

2. Post-radiation obstruction.
3. Preoperative and postoperative.
 - a. Radical neck or maxillo-facial resection.
 - b. Laryngectomy.
 - c. Hemorrhage into paratracheal structures after thyroidectomy.
- B. Inflammation of the respiratory passages or surrounding structures.
 1. Acute laryngotracheal edema (including post-intubation).
 2. Ludwig's Angina, severe.
 3. Diphtheria.
 4. Chronic granulating processes.
- C. Extensive burns of respiratory passages.
- D. Inability to establish or maintain an airway by conventional means.
- E. Following traumatic removal of foreign body from trachea.

Functional Disturbances

- A. Maxillo-facial injuries, particularly when combined with head, neck or chest injuries.
- B. Following pulmonary surgery in patients with moderate to severe impairment of ventilatory function.
 1. Advanced pulmonary emphysema or fibrosis.
 2. Inadequate functional reserve.
- C. Fracture of larynx or trachea.
- D. Crushed (Flail) chest.
- E. Impaired neuromuscular mechanism resulting from injury or disease.

Accumulated Secretions

- A. Unconscious or semiconscious patient.
 1. Head injuries.
 2. Cerebrovascular accident.
 3. Drug poisoning (barbiturate, narcotics, etc.).
 4. Systemic toxicity (uremia, septicemia).
 5. Postoperative neurosurgical patient.
- B. Conscious patient
 1. Debilitated patient—postoperative.
 2. Severe chest injury.
 3. Respiratory burns.
 4. Poliomyelitis or encephalitis.
 5. Injury of cervical and upper thoracic cord.

6. Metabolic disorders (myesthesia gravis).
7. Acute hemorrhage following bronchoscopic biopsy.

TECHNIQUE OF PERFORMING A TRACHEOSTOMY

A competent anesthesiologist should be able to perform a tracheostomy skillfully whenever the situation warrants. This is not to say he should perform this surgical procedure electively as part of his special services. He should obviously defer to a surgeon trained in the technique of tracheostomy, should one be present. However, since one of the basic responsibilities of the anesthesiologist is management of the airway in such a manner as to insure adequate alveolar ventilation at all times, it is obvious that this must include the ability to perform a tracheostomy should it be necessary.

The fine points of surgical technique as well as the instruments and sutures needed are described in most basic surgical texts,² and therefore will not be discussed. Obviously, the procedure is best learned under optimal conditions in the operating room with instruction from a skilled surgeon. The primary considerations are as follows:

(1) Whenever possible, tracheostomy should be performed in the operating suite where adequate lights, maximal facilities and trained personnel are available. The patient's room should be utilized only in emergency situations.

(2) Oxygenation of the patient by mask, or endotracheal tube if necessary, allows the surgeon more time to perform an adequate tracheostomy. Hypoxic patients are restless and unreasoning; it is difficult to obtain their cooperation.

(3) The anesthesia for this procedure varies from none in acute emergencies to the utilization of an already existing general anesthesia for an elective tracheostomy postoperatively. In most instances, infiltration of the neck tissues with a local anesthetic drug is the method of choice.

(4) Place the neck in a hyperextended position.

COMPLICATIONS

The performance of a tracheostomy, even when urgently indicated, by no means assures a successful outcome. Although the operation in itself may be lifesaving, serious complications occur with such frequency that it would be unwise to proclaim it a simple, harmless procedure. However, most of the complications are preventable. As with most medical problems, prophylaxis is the preferred method of treatment. The highest incidence of complications occurs in young children, particularly under one year, and in patients on whom an emergency tracheostomy has been performed. Complications may be divided into those related to the surgical procedure and those related to postoperative care.

SURGICAL COMPLICATIONS: Most of the complications related to the surgical procedure follow emergency operations where good technique has been sacrificed due to the urgency of establishing an airway. Others are related to errors in surgical technic and judgment.

Tracheal Stenosis. This sequela was once considered the most frequent and serious complication. Its occurrence is related to high tracheostomy where the tracheal incision is close to the cricoid cartilage. Tight suturing of the tissue around the tracheostomy tube is also said⁴ to be a principal cause of tracheal stenosis. Contamination may also contribute to the development of stenosis.

Hemorrhage after Tracheostomy. Gross hemorrhage is a relatively uncommon complication, but if it occurs, it is a most serious one. It is due to malposition of the tracheostomy tube with erosion into a blood vessel. Reinsertion of a clean or dislodged tracheostomy tube is frequently the precipitating trauma. It is most likely to occur in small children, and death may follow if adequate facilities for managing the patient are not available immediately.

Pneumothorax and Mediastinal Emphysema. Routine roentgenographic examinations reveal a higher incidence of this complication than would be suspected from clinical observation. It is usually not serious unless a tension pneumothorax develops following rupture of the mediastinal pleura where mediastinal emphysema has occurred. The incidence of

this complication is reduced if the tracheostomy is performed in patients whose trachea has been intubated to overcome or prevent partial respiratory obstruction.

Apnea Immediately after Tracheostomy. Although this is not common, the result may be fatal. Various hypotheses have been offered for this phenomenon. The most acceptable one to the author⁵ is that of rapid reversal of a pre-existing respiratory acidosis resulting in cardiovascular collapse and respiratory failure secondary to inadequate medullary blood flow. Blood pressure and pulse should be recorded before tracheostomy and postoperatively every ten minutes for one hour. If hypotension develops, the patient should be placed in Trendelenberg's position and a vasopressor drug used if necessary. One hundred percent oxygen should be used cautiously in order not to interfere with the effect of the chemoreceptors on the respiratory center.

POSTOPERATIVE TRACHEOSTOMY CARE: Tracheostomy alters physiology of respiration and presents unique problems that must be appreciated by the attending physician. This requires that an organized and efficient program for tracheostomy care be instituted to assure maximal benefit to the patient.

In bypassing the nasopharynx and larynx, two major problems arise: (1) the cough mechanism is impaired since the individual is unable to remove adequately material in the tracheobronchial tree or to expectorate effectively secretions that accumulate in the oro- or hypo-pharynx. (2) The inspired air does not receive the water vapor that it ordinarily obtains from the nasal mucosa. This results in thickening and inspissation of secretions to the point of crusting. Management is therefore centered around the correction of these physiological trespasses.

Instructions to Nursing Personnel. The care of the patient with tracheostomy requires around-the-clock vigilance. It is usually relegated to nursing personnel, whose experience may be limited. This may be improved by the preparation of an instruction pamphlet to be used by the nursing arts instructor and also added to the chart of each patient with tracheostomy. This pamphlet should give exact instructions to the nursing staff caring for the individual patient. It should include a

brief description of the purpose of the procedure, the equipment needed for its care, general instructions, technique for aspiration of secretions, maintenance of sterile technique, care of the tracheostomy, cannula and other equipment, and management of humidification and secretions wherever an oxygen therapist is not available. It is most important that the responsibility for the care of patients with tracheostomies be fixed on one department.

Care of Tracheostomy Tube and Cannula. The tracheostomy tube should be removed and a sterile one of similar size substituted on approximately the third postoperative day. Subsequent exchange should take place every 48 hours thereafter until the tracheostomy is to be discontinued. The tracheostomy tube should always be changed by a physician, but the cannula may be cleansed by the nursing personnel. The cannula must be removed and thoroughly cleansed every 8 hours, or more frequently as necessary to maintain patency of the lumen.

The following precautionary measures should be taken when exchanging the tracheostomy tube. (1) Use a source of light that is adequate for examining the tracheostomy orifice, locating the tracheal orifice for reinsertion of the tube and identifying bleeding points that might be present. (2) Have hemostats and retractors as well as other necessary equipment available on an emergency tray for securing hemostasis. (3) Have a suction apparatus available. (4) Be sure the means are available for ventilating the patient's lungs during this period.

Maintaining Humidification. Since inspired air bypasses the upper respiratory passages in the tracheostomized patient a problem of humidification in the tracheo-bronchial tree is presented. The upper passages are largely responsible for warming and humidifying air to the extent that by the time most air reaches the trachea it is at body temperature and approximately 100 per cent saturated with moisture. Failure of the inspired air to receive this conditioning results in excessive drying of the surface mucosa of the trachea and progressive inspissation of exudates and secretions, with subsequent encrustation frequently encroaching upon the airway.

The humidity necessary to prevent the ill

effects of drying in tracheostomy breathing ranges from the minimum conditions necessary to prevent discomfort or alteration of mucosa in the nose to the normal tracheal inlet conditions of near body temperature and near 100 per cent saturation (near 100 per cent body humidity). High relative humidity seems more important than high temperature to prevent drying, since even at the same absolute humidity warmer air will result in a slightly higher mucosal temperature and thus increase the mucosa air water tension gradient.* When drying is already present, maximal humidification must be used. Instillation of liquid water and the utilization of mists will aid in the moistening and removal of the exudate. Should the exudate and secretions become excessive, especially in the smaller bronchi, the use of hygroscopic, wetting and enzymatic agents is indicated.

Providing humidification is a major problem. The utilization of a "fog room," wherein a supersaturated atmosphere at a controlled comfortable temperature is provided the patient, is one of the acceptable methods. The body humidity provided is far from ideal, although it does conserve body water. Unfortunately, should supplemental oxygen be indicated it must be administered by nasal catheter.

The most effective method in current use is the utilization of a nebulizer with a heating element that provides a near normal body humidity to a plastic tracheostomy collar (fig. 2).^{*} The heating element shown is thermostatically controlled immersion unit that will warm the nebulizer to operating temperature (140 F.) within 10 minutes. It is provided with earthing means to prevent hazardous shocks and is sealed to prevent tampering or the influx of moisture. The unit, utilizing an oxygen flow rate of 4 to 8 liters per minute, will deliver to the distal orifice of a 7/8-inch nominal internal diameter corrugated tube 4 feet long an issuant gas with a relative humidity in excess of 100 per cent at body temperature (98.6 F.). The excess humidity has no real meaning and is carried as particles in suspension. The nebulizing unit has

* This heated, nebulizing unit is manufactured and distributed by the Puritan Gas Corporation, Kansas City, Missouri.

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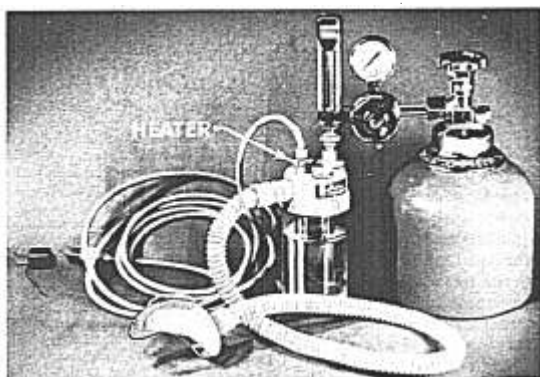


FIG. 2. A heated nebulizer unit.

built-in air diluter for administration of 40 per cent or 70 per cent oxygen concentrations. One disadvantage of this type unit is the possibility that surges of condensate might be inhaled by the patient due to the increased quantity of water delivered with the increased operating temperature.

Numerous other nebulizers have been utilized for providing increased humidification, but have not proven satisfactory due to their low operating temperatures.

The addition of balanced detergent mixtures such as Alevoire and Tergemist aid in the control and elimination of tenacious secretions and crusts. Digestive enzymes such as trypsin (Tryptar) may also be used. Most nebulizers function at flow rates of 4 to 10 liters per minute, which is adequate for delivery of these medications. The nature of the clinical situation as well as patient response determine the frequency of their administration. This varies from one hour three times a day to continuous administration.

Occasionally bronchodilators, antihistamines, antibiotics and vasoconstrictors are indicated and they may also be administered via the nebulizing technics described.

When the previously described methods of humidification are unavailable, a moist gauze sponge to act as a flap over the tracheostomy opening may be utilized. Room air is then

moistened as it is drawn through the sponge. Obviously, this is grossly inadequate.

Suctioning. Ineffective aspiration of tracheal secretions is the major problem of nursing care. Inexperienced individuals frequently fail to pass the suction catheter to a sufficient depth. They may also leave the catheter in place for too long a period and allow insufficient time for oxygenation between suctioning attempts. Failure to recognize the need for aspiration allows secretions to collect and inspissate. Crusting of the secretions and obstruction of the airway follows. The suction catheter should not remain within the cannula longer than 10 seconds, unless the situation so warrants, and the interval between suctionings should be such that the patient has time to reoxygenate. A separate catheter should be used for oral and tracheal suction and sterile technics adhered to. Aqueous benzalkonium solution (Zephiran) 1:10,000 is recommended⁹ for storing the suction catheters between aspirations.

Other Complications. These include wound infection, air embolism, fistula, and reactions to the local anesthetic drug.

SUMMARY

Tracheostomy is occasionally the only means available for establishing and maintaining an effective airway. Although it is rarely neces-

sary for the anesthesiologist to utilize this procedure in providing an airway during anesthesia, his knowledge of respiratory physiology and the frequency with which he comes in contact with patients who are in need of the procedure makes it mandatory that he assume responsibility for urging and, if necessary, performing indicated tracheostomies, and seeing that they are properly managed.

The indications for tracheostomy have increased considerably in recent years. Where the procedure was originally used only as a bypass for mechanical respiratory obstruction, it is now employed frequently for aiding in the removal of secretions and in the correction of functional disturbances in pulmonary ventilation.

The anesthesiologist should be able to perform a tracheostomy should it be necessary. The major considerations in technic are presented, and the complications arising from the altered respiratory physiology and from the surgical procedure itself are discussed. In bypassing the larynx, impairment of the cough

reflex and of the humidifying processes pose the major problems of postoperative care.

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PLACENTA Blood samples were drawn nearly simultaneously in pregnant does from a uterine artery and vein and an umbilical artery and vein after the uterus had been delivered by a midline abdominal incision and opened by a small cut at right angle to the long axis of the horn. In the normal study as judged by maternal arterial blood pressure greater than 90 mm. Hg and an arterial oxygen saturation of 96 per cent or over (P_{O_2} equals 74 to over 90 mm. Hg), the partial pressure of oxygen in blood leaving the uterus ranged between 38.2 and 54. mm. Hg. Since

the coefficient of oxygen utilization by the uterus and its contents was low (20-32 per cent), the oxygen pressure in the maternal placental capillaries was high. The oxygen pressure in the umbilical artery varied between 10.4 to 18.5 mm. Hg. The reasons for the gradient between maternal and fetal blood is unknown, but it appears to be the result of mechanisms not primarily determined by the structure of the placenta. (Prystowsky, M., Meschia, G., and Barron, D. H.: Oxygen Tension in Placental Bloods of Goats, Yale J. Biol. & Med. 32: 441 (June) 1960.)