

RESPIRATORY OBSTRUCTION AT THE GLOTTIC LEVEL *

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RESPIRATORY obstruction usually indicates the presence of some degree of "asphyxia," a term that is at times used interchangeably with "anoxia." Strictly speaking, the word asphyxia should be restricted to conditions in which there is anoxia combined with an increased tension of carbon dioxide in the blood and tissues (1). Historically, the word asphyxia comes from the Greek where the term was used to indicate a stoppage of the pulse. To correct this condition it is believed that early man may have performed tracheotomy, and certainly it appears that the surgeons of Italy and France practiced this procedure as a surgical routine in the twelfth and thirteenth centuries. The first successful modern tracheotomy was carried out in 1828. Another approach to the correction of respiratory obstruction is intubation of the larynx, which was originally suggested by Hippocrates. This was not accomplished successfully until the first quarter of the nineteenth century. The technic for tracheal intubation was perfected largely through the efforts of O'Dwyer who attempted to avoid the older practice of tracheotomy (2).

Anoxic spasm of the laryngeal muscles and vocal cords may result from stimulation of the laryngeal mucosa or perhaps from stimuli arising at the operative site (3). It is most frequently seen in poorly premedicated and vigorous, muscular individuals. The aducted cords are covered by the tightly approximated folds of the false vocal cords. In addition, the aryepiglottic folds close the larynx with a sphincter-like action (4).

A severe complication of spasm of the larynx or respiratory obstruction above this level is pulmonary edema as a result of protractive or excessive negative pressure in the alveoli (5). In most instances, laryngeal spasm can be readily corrected by positive pressure on the breathing bag of the anesthesia apparatus, using a well-fitting face mask.

Laryngeal edema is one of the possible, though rare, complications that may follow repeated, traumatic or prolonged tracheal intubation (6). The edema is limited chiefly to the aryepiglottic folds

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which encroach upon the airway. It is recalled that the true vocal cords contain only a small quantity of areolar tissues and are capable of only a minimal amount of edema. This type of obstruction occurs within a few hours after termination of the procedure. It has been attributed to a streptococcal infection brought about by the entrance of organisms into small abrasions of the mucosa (7). In so far as possible, sterile precaution might be wisely employed, especially in the equipment used for children.

Clinically, these patients manifest anxiety, dyspnea, stidor, tachypnea and tachycardia. They must use their accessory muscles of respiration, with the result that there is retraction of the supraclavicular and intercostal spaces on inspiration. If the obstruction is prolonged and severe, the patient may become drowsy and "sleep away" without a struggle (8).

For control, on an emergency basis, the spray or direct application of a 5 per cent solution of cocaine to the edematous area has been recommended (9). Lesser degrees of edema may also be treated by spraying with a 1:100 solution of epinephrine or by multiple puncture of the edematous tissues to release the fluid. However, it has been firmly established that the treatment of acute laryngeal obstruction is immediate tracheotomy. If an endotracheal tube can be inserted through an edematous larynx, it is advantageous to do so first because tracheotomy can then be performed in an orderly manner and without hurry (6). It must be realized that the anesthesia necessary for this procedure is especially dangerous as the production of unconsciousness in a patient who is obliged to use his accessory muscles of inspiration may cause death (3). Certainly, the insufflation of adequate quantities of oxygen from the onset of anesthesia is indicated. The use of morphine for preanesthetic medication, and also the use of basal anesthesia are dangerous and should be avoided.

The formation of a subglottic membrane is another type of post-endotracheal complication that leads to respiratory obstruction (10). This condition is relatively uncommon, especially in the adult. It develops acutely within twenty-four to forty-eight hours after endotracheal anesthesia. The clinical picture is that of laryngeal edema. However, upon examination of the larynx, the glottic chink and epiglottis appear normal and there is no evidence of edema. Bronchoscopy reveals an adherent subglottic membrane as the cause of the obstruction. To explain the formation and mechanism of a subglottic membrane, it is necessary to review the anatomy of the larynx where the subglottic area is the narrowest portion. It is completely surrounded by the cricoid cartilage, which forms a rigid circle with the mucosa loosely attached. The type of mucous membrane and the looseness and vascularity of the submucous tissue predispose to the formation of edema which may result from irritation (11). A matter for consideration is the effect of a uniform edema of 1 mm. in reducing

the cross-sectional area of the space through which the respired gases must pass. In the infant, the decrease in the area may be as great as 75 per cent, producing serious respiratory difficulty, whereas, in the adult, the decrease in area may be less than 20 per cent with little or no resulting respiratory distress. Also significant is the fact that the edema may be in excess of 1 mm. and that it may not be uniform in distribution. A subglottic membrane develops by means of an accumulation of leukocytes and desquamated epithelial cells about the abraded area. The membrane usually forms on the anterior aspect of the cricothyroid region and may come in contact with the inferior surface of the vocal cords which, in addition to impeding respiration, may produce reflex adduction of the vocal cords.

Trauma to the subglottic mucosa can follow an apparently non-traumatic intubation. Prolonged pressure against the mucosa by a deflated and wrinkled endotracheal cuff may produce minute superficial abrasions. Trauma is more likely to occur when the caliber of the endotracheal tube and cuff is too large for the diameter of the trachea. The entire cuff, when used, should be positioned below the cricothyroid mucosa, and a tube that cannot be advanced through the cricoid ring should be removed and replaced with a smaller tube, or the anesthesia completed without endotracheal intubation. The presence of a tube, between the cords, that is too large to enter the trachea will irritate the mucosa as a result of the movement of the larynx which is synchronous with respiration.

In 3 reported cases of subglottic membrane that occurred in adults, the endotracheal tubes and cuffs fitted so snugly in the trachea that it was not necessary to inflate the cuff. Also, a sense of firm resistance was encountered during extubation (10). This type of case can be successfully managed by bronchoscopy and complete removal of the debris and the entire membrane. If this is accomplished, tracheotomy is usually not necessary. In children, bronchoscopy is regarded as more traumatic procedure than tracheal suction with the catheter.

CASE REPORTS

Case 1.—A 4 year old white girl was operated on for excision of a cyst of the thyroglossal duct. The anesthesia consisted of open drop vinethene-ether sequence, and then nasotracheal intubation with a number 23 French Magill tube, which was accomplished without difficulty and was considered to be atraumatic. The operation lasted two hours and it was necessary to manipulate the tongue and surrounding structures, and to excise a portion of the hyoid bone during the procedure. On the day after operation, the patient had a rather marked degree of hoarseness but apparently could respire adequately.

The next day, a moderate degree of respiratory obstruction developed, and "laryngitis" persisted. The major difficulty was present during inspiration, at which time there was suprasternal and intercostal retraction. At times, there was slight evidence of cyanosis. The patient was observed throughout the day,

with no improvement. At approximately 10 p.m. (2200 hours), it was elected to carry out a tracheotomy under ether endotracheal anesthesia. Without premedication, anesthesia was induced with open drop vinethene and ether. Oxygen was insufflated at a high rate of flow from the onset, and the patient's color remained excellent at all times. Respiratory obstruction on inspiration was severe and it was difficult to obtain an anesthesia level below upper first plane. The pulse rate and rhythm were always satisfactory, although just before induction a cardiac irregularity had developed. It was decided to attempt nasotracheal intubation with a number 23 French tube even though the patient was in light anesthesia. This was accomplished with some difficulty and while the anesthetist was adjusting the endotracheal tube, the patient vomited and the tube was completely dislodged. It was then noted that the respirations had markedly improved and the child was able to respire freely. When the vomitus initiated coughing on the part of the patient, a large amount of coagulated mucus was expelled from the trachea. This was believed to be part of a subglottic membrane.

During recovery there was further vomiting and coughing, and more coagulated mucous material was expelled. The patient was returned to the ward in apparently excellent condition, breathing easily, and with all vital signs normal. Recovery was uneventful. The laboratory diagnosis after examination of the material coughed up from the larynx and trachea was "membrane, inflammatory, acute."

Case 2.—A 4 year old negro boy underwent surgical repair of a left diaphragmatic hernia through a thoracotomy approach. Anesthesia consisted of open drop vinethene and ether followed by atraumatic oral intubation of the trachea with a number 26 French cuffed tube, which was inserted without difficulty. The tube fitted quite snugly and it was not necessary to inflate the cuff. The operation lasted approximately four hours and, technically, was uneventful. The patient was returned to the ward in excellent condition.

On the morning following the surgical procedure, it was noted that the patient was in moderate respiratory distress. There was partial obstruction on inspiration, manifested by retraction of the supraclavicular and intercostal spaces with dilatation of each ala nasi. The child was observed throughout the day, but the obstruction persisted in spite of several attempts to suction the trachea with a catheter and encouraging the patient to cough. At 10:30 p.m. (2230 hours) it was decided to establish an airway before the patient's condition deteriorated further. He was brought to the operating room without premedication and anesthetized with open drop vinethene and ether, adequate quantities of oxygen being insufflated from the onset of anesthesia. Obstruction on inspiration was rather pronounced and it was difficult to bring the anesthesia level below the upper to mid first plane of ether anesthesia. Tachycardia was marked, the pulse being 160 and the respirations labored. As soon as the mouth could be opened partially, orotracheal intubation was performed without difficulty, using a number 23 French tube. A satisfactory airway was immediately established and no further anesthesia was administered. The trachea was suctioned several times and large quantities of thick secretions were removed. The presence of a subglottic membrane was not definitely ascertained. There was marked salivation and some vomiting because of light anesthesia. All secretions were suctioned and the airway remained patent. When it was ascertained that there were no more tracheal secretions, the endotracheal tube was removed, with

catheter suction in place. The patient's respirations were closely observed and found to be adequate, unobstructed and apparently normal in function. The tachycardia subsided shortly after the trachea was intubated. The patient was returned to the ward in good condition and in no respiratory distress. He was observed the following morning and found to be in satisfactory condition.

On the third postoperative day, marked respiratory distress suddenly reappeared. Without preanesthetic medication, the child was anesthetized and intubated as before. After suctioning a moderate amount of secretions from the trachea, a clear airway was established. The endotracheal tube was then removed and the airway remained patent. The patient was returned to the ward in apparently satisfactory condition, respiring freely and without any manifested obstruction.

Again on the fourth postoperative day, the respiratory obstruction recurred and it was decided to perform a tracheotomy under endotracheal anesthesia. Preanesthetic medication consisted of scopolamine, 0.3 mg. The induction was relatively uneventful but, as before, it was difficult to obtain any depth of anesthesia. Marked cardiac arrhythmia, attributed to hypoxia, was present prior to induction. Oxygen was insufflated at a high rate of flow from the time induction was begun. When the larynx was visualized at the time of intubation, a pronounced degree of edema of the aryepiglottic folds was recognized and the vocal cords could not be clearly seen. Immediately upon inserting an oral tracheal tube, a clear airway was established and the cardiac arrhythmia subsided. The pulse also slowed to a more normal rate. On this occasion, the trachea was quite dry, indicating that the cause of the obstruction was at the level of the larynx. Tracheotomy was carried out uneventfully, the endotracheal tube being withdrawn with suction with the simultaneous insertion of the tracheotomy tube. The patient was returned to the ward in good condition and recovery was uneventful.

DISCUSSION

One of the most common and pernicious complications of anesthesia and a serious postoperative development is obstruction of the airway. The accompanying hypoxia and prolonged accumulation of carbon dioxide fatigue the respiratory center, leading to further deterioration of the patient's condition. It is of great significance that the isolated existence of only one type of anoxia for any considerable period of time probably is rare, if not impossible. The onset of one form may establish a cycle of events which will rapidly initiate other forms of oxygen want (12).

Oxygen is the most vital of all the substances required for life, and yet the body is unable to store it in appreciable amounts. Its deprivation for more than a few minutes will prove fatal to the organism or severely damage vital structures. Similarly, interference with the elimination of carbon dioxide may also prove fatal, or markedly disturb the physiology. Since the efficient transport of both oxygen and carbon dioxide is dependent upon normally functioning circulatory and respiratory systems, any disturbances of these mechanisms controlling gaseous movements, either by drug or disease, and alterations

of respiratory and circulatory channels, are to be avoided. Cell damage is directly proportional to the interference with gaseous exchange, and derangement of vital functions is a sequence of the resulting depression, regardless of the cause. In the presence of hypoxia, the brain centers assume lowered levels of activity and there is a diminished effort of the respiratory tract to expel foreign material. At the same time, laryngeal functions are depressed and consequently mucus and other substances may gain entrance to the air passages. One of the common dangers is a lessening of muscle tone (13).

The management of obstruction, located above the glottic level, ordinarily presents no difficulties. Spasm of the vocal cords and ventricular folds (14) is a very real respiratory emergency, but it will usually respond to appropriate therapy. There appears to be little controversy that tracheotomy should be performed in the presence of significant edema of the laryngeal structures. It is emphasized that, whenever possible, intubation of the trachea should be carried out prior to surgery, thus permitting the operation to be conducted in an orderly manner and without further trauma to the patient. Obstruction to the respiration below the glottic level presents problems in management, the issues of which cannot be definitely settled. If a skilled anesthetist or surgeon is available, it appears that a subglottic membrane can be effectively removed in the adult through the use of efficient bronchoscopy and thorough tracheal toilet. In children, the nontraumatic insertion of an endotracheal tube with suctioning of the tracheobronchial tree may be an effective measure. Should respiratory obstruction recur, tracheotomy is indicated. The repeated insertion of an endotracheal tube, regardless of the skill with which it is introduced, is likely to be followed by some edema of the laryngeal structures. Its encroachment on the airway in children is not readily tolerated. Small patients should not be subjected to prolonged or frequent bouts of respiratory obstruction and its accompanying hypoxia.

From experience, it has been learned that obstruction to respiration is, or appears to be, a self-perpetuating condition and one that does not lend itself to spontaneous correction. To procrastinate in the therapeutic approach to this problem is fraught with great danger. As the obstruction persists, the patient's condition becomes less satisfactory to withstand corrective measures. Conservative efforts to alleviate the obstruction are usually not successful. In the presence of respiratory obstruction, measures toward corrective management should be instituted early so as to insure an effective outcome.

SUMMARY

Some of the more common types of laryngeal respiratory obstruction are presented. An effort has not been made toward completeness; for further information, reference to standard textbooks and clinical

literature is recommended. Stress has been placed on obstruction at the glottis and immediately below this level, and 2 illustrative cases are reported.

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