delayed several days for the patient presented herein, yet even with a short segment of the trachea present, considerable instability of the airway was encountered.

In selected cases of tracheal atresia surgical palliation is possible. The first surgical correction of this condition with survival beyond the immediate postoperative period was reported in 1963. This infant’s trachea ended just inferior to the vocal cords; ventilation was possible because of an associated bronchoesophageal fistula. At 36 hours of life the patient underwent a cervical esophagostomy and feeding gastrostomy. The distal esophagus was divided and a respiratory passage composed of esophagus leading to the bronchi was brought out to the skin; thus, an “esophageal tracheostomy” was constructed. Other children with congenital tracheal malformations have been operated upon successfully, and a recent report details the resection of a 17-mm hypoplastic segment of trachea in a 4-month-old infant. Our patient was potentially salvageable because of the presence of distal trachea.

In summary, we wish to emphasize the following points: 1) The diagnosis of tracheal atresia with bronchoesophageal fistula or bronchoesophageal fistula should be considered when one can neither advance nor ventilate through an endotracheal tube, especially when ventilation via bag and mask proves successful; 2) initial treatment consists of assisted ventilation by bag and mask. Although attempts at endotracheal intubation should cease, a tube in the esophagus may improve ventilation; 3) an early attempt at surgical palliation (or correction) should be undertaken when the airway is inadequate or unstable. If exploration reveals the presence of a bronchoesophageal fistula, the desirability of further therapy is debatable.

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**Unilateral Pneumothorax Following Jet Ventilation during General Anesthesia**

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Jet ventilation has become an accepted and practical technique during anesthesia for laryngoscopy, fiberoptic bronchoscopy and certain head and neck surgical procedures involving invasion of the airway. However, complications such as pneumothorax and abdominal distention have been reported. This is the case report of unilateral pneumothorax secondary to endobronchial intubation with the jet catheter.

**REPORT OF A CASE**

A 73-year-old woman weighing 47 kg was admitted with a diagnosis of recurrent squamous cell carcinoma and scheduled for direct laryngoscopy and biopsy. She had no history of cardiopulmonary problems; preoperative roentgenogram of the chest was normal, and electrocardiogram was within normal limits. All laboratory values were within normal limits with except serum potassium, which showed slight hypokalemia (serum K+ = 3.3 mEq/l).

Hydroxyzine, 50 mg, im, and atropine, 0.4 mg, im were given 60 min before operation. Arterial blood pressure was 100/70 torr. Thiopental, 160 mg, iv, was given, followed by inhalation of halothane, nitrous oxide and oxygen. The patient was then positioned with a roll under the shoulders and a Jackson laryngoscope...
was used to expose the glottic opening, after which a 3.5-mm jet catheter was insertedatraumatically. The vocal cords appeared slightly edematous, but the glottic opening was adequate for exhalation. No obstruction to ventilation was evident, and breath sounds were present bilaterally. Ventilation was controlled at a rate of 10–16/min with a pressure of 15 psi. Anesthesia was maintained with fentanyl, 0.1 mg, thiopental, 400 mg, and intravenous infusion of succinylcholine. During the procedure, systolic blood pressures ranged from 85 to 100 torr and heart rates from 90 to 110 beats/min. Chest expansion was adequate and symmetrical throughout the procedure, and exhalation was unobstructed. After multiple biopsies of the base of the tongue, the procedure was terminated and the drapes and shoulder roll removed. The operation lasted 50 min and the total dose of succinylcholine was 120 mg. Naloxone, 0.4 mg, iv, was administered to reverse narcosis and respiratory depression. Jet ventilation was maintained until spontaneous ventilation was deemed adequate.

The patient became responsive 5 min later, but respirations were labored and tachypneic. There was slight limitation of motion, and breath sounds by auscultation over the left side of the chest were diminished. With $P_{\text{ET}}$ 1.0, $P_{\text{H2}}$ was 7.34, $P_{\text{CaO2}}$ 47 torr, $P_{\text{CO2}}$ 38 torr, and base excess was −1 mEq/l. A portable chest roentgenogram revealed left tension pneumothorax with total collapse of the left lung and displacement of the mediastinum to the right. The tip of the jet catheter was found to be in the left main bronchus (fig. 1). A 20-Fr chest tube was placed in the left midaxillary line at the level of sixth intercostal space. The follow-up chest roentgenogram showed reexpansion of the left lung and a midline position of the mediastinum. Only a residual pneumothorax was seen in the apical area. The chest tube was removed 24 hours later, and the patient’s respiratory status remained stable.

**DISCUSSION**

Jet ventilation has proven to be a practical technique and is well accepted by surgeons for endoscopic procedures such as laryngoscopy and fiberoptic bronchoscopy. Before the jet catheter was introduced for laryngoscopy, jet laryngoscopy using an injector attached to the laryngoscope was used for high-pressure ventilation. The disadvantages include danger of blowing particles into the lower respiratory tract, movement of vocal cords during ventilation, danger of blowing gas into stomach, and inability to ventilate the patient during pharyngeal biopsy. A case of pneumothorax because of debrided tumor going down to a bronchus, causing ball-valve obstruction, was reported recently.

By using a pediatric chest tube, 3.5 mm in diameter, as a jet catheter, not only is there enough space for the surgeon to manipulate, but the airway is secured throughout the procedure; however, the catheter will not function as a pathway for exhalation, and constant surveillance of passive outflow is necessary. A case of severe abdominal distention following jet ventilation and three cases of pneumothorax, including this case, have occurred in the past two years in our institution. Our incidence of pneumothorax is then about 0.5 per cent (3/600). Two of the patients had bilateral pneumothorax. One patient was undergoing excision of recurrent papilloma of vocal cords, and the other was scheduled for excision and biopsy of vocal-cord carcinoma. In both cases, the glottis was moderately narrow because of the lesions, and in spite of careful application of the jet ventilation, bilateral pneumothorax occurred. The patient who had vocal-cord carcinoma died in intensive care unit after 24 hours because of irreversible cerebral insult after prolonged resuscitation.

In the case presently reported, the lesion was at the base of the tongue; the vocal cords were intact. After insertion of the jet catheter, breath sounds were present bilaterally, and adequate passive exhalation was observed throughout the operation. The patient’s neck was hyperextended by placement of a roll under her shoulders throughout the 50-min procedure. The roll was removed at the end of the surgical procedure while she still was receiving jet ventilation. The trachea can move with respiration and with alterations in the position of the head. Extension of the neck can increase the length of the trachea by as much as 23 to 30 per cent. The normal length of the trachea is about 10 cm. Therefore, when the neck is severely hyperextended, the trachea will lengthen to about 13 cm. Since the vital signs were stable and check expansion was symmetrical throughout the procedure, we speculate that in this case the tip of the jet catheter may have been just above the carina during the procedure; however, when the roll was removed and the patient placed in supine position, the catheter entered the left bronchus. The left unilateral pneumothorax occurred because of high-pressure ventilation after left endobronchial intubation at the end of the procedure.

**FIG. 1.** Left endobronchial intubation resulting in left pneumothorax (schematic representation of the original roentgenograph, which was not adequate for publication).
Schellinger suggested the distance between the upper border of cricoid cartilage and the tip of the xiphoid process correlates well with the length of the airway to the bifurcation of the trachea. In case of high-pressure jet ventilation, we question whether this is a safe guideline.

Since this episode, we have insisted on direct constant visualization of the proximal black ring on the tube we use (Argyle®, Brunswick Company) which is 9.5 cm away from the distal end during the endoscopic procedure. At the end of each procedure, we recommend that the patient not be ventilated with the jet after the shoulder roll is removed to restore the normal supine position. The pad may be removed and ventilation controlled via mask, while the jet catheter remains in place as an emergency airway.

We again stress that constant vigilance of outflow is necessary with this technique. Laryngeal obstruction of only brief duration can result in high alveolar pressure and lung volume with this technique. This potential is especially high since this technique is most frequently used in situations where edema and/or disease is present in the airway. Both edema and disease were present in this case, and we cannot completely rule out this mechanism, although no obstruction was evident and chest expansion was symmetrical until the shoulder roll was removed.

We report this case to emphasize that endobronchial intubation is another cause of pneumothorax during high-pressure jet ventilation.

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Failure of Battery-operated Alarms

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During the administration of an anesthetic, the anesthesiologist obviously should be certain that the apparatus being used is functioning properly. Cooper et al.¹ found that improper or inadequate design of equipment was involved in many of their reported anesthetic mishaps. One approach to help warn of equipment failure has been to devise monitor/alarm systems for anesthesia apparatus. However, these monitor/alarm systems can also fail. For example, Pierran et al.² showed that when battery voltage declined, the original electrode biasing circuit for an oxygen concentration monitor caused an erroneously high reading in the presence of nitrous oxide. Monitors, unchecked or improperly used, can create a hazardous situation by providing the anesthesiologist with a false sense of security.

This report describes the failure of two different battery-operated monitor/alarms: the Instrumentation Laboratories IL 402 Oxygen Alarm Monitor®, and the Dräger D.P.M. Pressure Monitor®.

IL 402 Oxygen Alarm Monitor

The purpose of the oxygen alarm monitor is to monitor continuously the inspiratory oxygen concentration and to provide an audiovisual alarm if the oxygen concentration falls below a preselected value. The monitor consists of a polarographic sensor, which is placed in the inspiratory limb of the anesthesia circuit, and appropriate electronics to read and