Spontaneous Dislocation of Endotracheal Tubes

IGNACIO RIPOLL, M.D.,* CARL-ERICK LINDHOLM, M.D.,† ROBERT CARROLL, M.D.,‡ AKE GRENVIK, M.D.§

The concern about laryngeal and tracheal injury from prolonged endotracheal intubation has led to development of softer tubes with large-diameter/low-pressure cuffs. While these innovations have decreased the incidence of pressure necrosis of the tracheal mucosa, they have also created new problems. For instance, nasogastric tubes and other esophageal devices may accidentally enter the trachea, unimpeded by the soft cuff of the tracheal tube.1

During 1975, in 18 ICU patients, we tested an experimental polyvinylchloride (PVC) tube, softer than those commercially available. Six of the 18 patients managed to "extubate" the trachea without using their hands, and despite firm fixation of the tubes to the face. On inspection, the six tubes were all found to be either looped in the mouth and pharynx or tortuously deformed. At that time, the mechanisms of tracheal tube dislocation were believed to include chewing, coughing, bucking, "tongueing," and moving the head. Because of the problem, the manufacturer was advised not to produce this soft PVC tube or to modify it to avoid this dangerous complication. More recently, however, patients in our intensive care unit have had similar spontaneous dislocations of commercially available PVC tubes. Two of these cases are reported here, and the likely causes of dislocation discussed, based on observations during experimental ventilation of a lung model and of cadavers.

REPORT OF TWO CASES

Case 1. A 56-year-old white man was hospitalized for elective total colectomy because of uncontrollable ulcerative colitis, unresponsive to medical therapy. Colectomy was uncomplicated, but during the first two postoperative days, severe respiratory distress developed. Roentgenograms of the chest revealed dense pulmonary infiltrates. At bronchoscopy, a large quantity of purulent material was removed. It grew Pseudomonas aeruginosa. The patient's condition deteriorated, and he was admitted to the intensive care unit for mechanical ventilation. A PVC tracheal tube, 8.5 mm I.D. was inserted orally under direct vision without difficulty. The cuff was seen to pass well below the vocal cords. Roentgenograms of the chest showed the tube in good position. The tube was secured to the face using tincture of benzoin and adhesive tape. Three hours later, an air leak developed. The tube was still firmly fixed to the face but distorted in the mouth, the cuff completely above the cords. This tube was removed, a second tube placed, and the cuff was again seen to pass below the cords. Exit of air from the tube was assuaged by pushing on the chest. The cuff was inflated with air until it was sealed. Breath sounds were heard by two examiners to be equal on both sides. Once more, the tube was routinely secured to the face as described above. Over the next 15 minutes, the patient's condition was stable. However, after a routine post-intubation roentgenogram of the chest, he became agitated, bradycardic, and then asystolic. When manual assistance of ventilation through the orotracheal tube was begun, a large air leak was immediately apparent, necessitating extubation and insertion of a third tube of the same type. The roentgenogram obtained immediately prior to cardiac arrest showed the orotracheal tube to be completely dislodged from the trachea, and its tip in the esophagus. Following cardiopulmonary resuscitation, until death 12 hours later, the patient remained totally unresponsive. A post-cardiopulmonary resuscitation portable chest x-ray film showed the tip of the third endotracheal tube 4 cm above the carina. Ventilation with a tidal volume of 1,000 ml and a positive end-expiratory pressure (PEEP) of 5 cm H₂O caused peak airway pressure to oscillate between 30 and 35 cm H₂O. Another roentgenographic examination 8 hours after cardiopulmonary
resuscitation showed the tip of the tracheal tube to be considerably higher than before, 8 cm above the carina, once more demonstrating a tendency to become dislodged, even though the patient was totally unresponsive and flaccid.

Case 2. A 53-year-old white man was admitted to the intensive care unit after triple aortoconary bypass, complicated by prolonged bleeding and cardiogenic shock. The patient needed four and a half hours of heart-lung machine support and then intravenous balloon counterpulsation to maintain adequate cardiac output. Orotracheal intubation was accomplished with a PVC tube, 9 mm I.D., which was connected to a volume-set ventilator with a tidal volume of 1,200 ml and PEEP, 12.5 cm H₂O, creating a peak inspiratory pressure of 42 cm H₂O. The patient was paralyzed when suddenly a significant air leak developed. The tracheal tube was firmly attached to the face, but the tube was distorted in the oral cavity with the cuff above the vocal cords. The tracheal tube was replaced with another #10 PVC orotracheal tube, which functioned satisfactorily.

Experimental Study

The two cases described above made it clear to us that our original theory about "tongueing" out soft endotracheal tubes could not be correct. Therefore, an experimental study was performed on a lung model with a specially designed translucent trachea, equipped with a narrow portion simulating the larynx. The inside of the mock trachea was lubricated with soap solution to imitate the slippery surface of the natural trachea. A tracheal tube of the soft experimental type was inserted into the mock trachea with the cuff totally below the simulated larynx. The tube was suspended on a peg board and permitted to move within the limits of the normal oropharyngeal space limits. Intermittent positive-pressure ventilation by a volume-set ventilator produced peak inspiratory pressures of 30 cm H₂O. This caused the intratracheal end of the tube to migrate cranially intermittently, until the upper portion of the cuff reached the "larynx." As the tube was fixed to the peg board, corresponding to the normal site of the teeth and lips, the tube distorted in the model oropharynx. Migration of the tube was synchronized with the intermittent positive pressure produced by the ventilator.

When the cuff was inflated at the level of the larynx, with part of the cuff above the "vocal cords," a few inflations by the ventilator suddenly made the tracheal tube completely pop out of the mock trachea.

Similar results were obtained with soft tubes inserted into laryngotracheal specimens obtained at autopsy instead of the mock plastic trachea, but with otherwise identical arrangements. Preheated to body temperature, the commercially available tracheal tubes of the type used in the two cases reported above also occasionally dislocated from the trachea when high peak pressures (more than 50 cm H₂O) were used in combination with PEEP 20 cm H₂O and lateral movements of the tube within the limits of the simulated oropharynx. Dislocation was not encountered when tubes with small volumes and high-pressure cuffs were utilized.

Discussion

Damage to the larynx and trachea is a well-recognized complication of prolonged endotracheal intubation. Lipman and Carroll have documented the range of forces exerted against the posterior laryngeal wall by commercially available tubes. They demonstrated that PVC tubes of the type used in the two cases presented here, particularly the experimental soft tubes, exert far less pressure against the posterior larynx than do traditional stiff red rubber tubes. This explains the greater injury to the posterior laryngeal wall often seen in the past, when red rubber tubes were more common. However, as demonstrated in this paper, the risk of spontaneous tube dislocation increases considerably when the tube material is too soft. Flexion and extension of the neck, as well as lateral tilting of the head, can change the position of the tip of the endotracheal tube closer to or away from the carina. With such movement of the head, tips of endotracheal tubes in adult patients have been noticed to move as much as 2 cm downward or upward in the trachea. Obviously, neck motion during placement of a film cassette behind the back for roentgenographic examination of the chest could have contributed to the dislocation of the endotracheal tube in our first patient.

Dimensional changes in the tracheobronchial tree in dogs have been documented during spontaneous breathing as well as during positive-pressure ventilation. It is not unlikely that ventilatory fluctuations in diameter and length of the trachea contribute to occasional dislocation of translaryngeal tubes.

Our observations support the concept that during intermittent positive-pressure ventilation there is a tendency to dislocate modern PVC tracheal tubes with low-pressure/large-volume cuffs, and the risk of dislocation increases with increased softness of the tube material. The force is applied during inspiration, when there is a gradient between the tracheal pressure below the cuff and the atmospheric pressure above the cuff while tracheal dimensions increase. When the airway pressure is not sufficiently opposed by tube stiffness, dislocation may occur, sometimes moving the tube completely out of the trachea, particularly when the tube is accidentally moved upwards, positioning the upper portion of the cuff between the vocal cords,
as probably happened in Case 1 during preparation of the patient for roentgenographic examination.

It should be noted that we have seen dislocation only in patients with orotracheal intubation, and not in nasotracheally intubated patients. The ability of the tracheal tube to resist distortion depends on the length and shape of the tube between the area of fixation and the cuff. Nasotracheal intubation offers some advantages over orotracheal intubation. There is better internal tube support and a relatively straighter course from the posterior nasopharynx into the trachea. This makes the nasotracheal tubes better able to resist forces generated by tracheal pressure against the cuff, because these forces merely lead to axial/longitudinal compression of the tube. With orotracheal intubation, on the other hand, the airway pressure forced on the tube results in bending, to which there is far less resistance than to longitudinal compression. Further, a longer portion of the orotracheal tube is without support, making it more easily distorted.

Accidental dislocation of the endotracheal tube into the pharynx, with or without secondary entrance into the esophagus, is an infrequent but life-threatening complication that may occur both during anesthesia in the operating room and in the intensive care unit. This problem may be prevented or at least minimized by: 1) nasotracheal intubation; 2) vigilance in observing the patient, especially during procedures that involve flexion and extension of the neck; 3) splinting of the orotracheal tube with a specially designed oropharyngeal airway or making the oral part of the tube stiffer; 4) careful observation of air leakage indicating that the cuff is located at the level of the vocal cords; 5) awareness that increasing distances between the tube tip and the carina on successive x-ray films indicate potential extubation; 6) development of orotracheal tubes pre-shaped according to the anatomy of the upper airway to avoid undue pressure on surrounding tissues, yet reinforced to resist the bending forces exerted on the cuff by airway pressure.

REFERENCES