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## Endotracheal Tube Obstruction by Nitrous Oxide

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Diffusion of nitrous oxide into the endotracheal tube cuff increases cuff size and pressure.<sup>1</sup> The following report describes a similar effect of nitrous oxide on a hidden air space within the inner wall of a latex, wire-reinforced endotracheal tube. The amplification of this bubble by diffusion of nitrous oxide resulted in severe intraluminal obstruction during the early intraoperative period.

### REPORT OF A CASE

A 58-year-old man with a four-year history of laryngeal papillomas was scheduled for direct laryngoscopy and cryosurgery. He had undergone general anesthesia many times in the past for similar operations and previously had had a tracheostomy because recurrent papillomas had partially obstructed his airway.

One hour before operation, the patient received meperidine, 50 mg, im. Anesthesia was induced with thiopental, 250 mg, iv, the tracheostomy tube was removed, and a 7.5-mm cuffed, latex, wire-reinforced (anode) endotracheal tube (Rusch®, West Germany) was placed directly into the tracheostomy stoma. This tube had been used many times. Enough air inflated the cuff to prevent gas leakage. Breath sounds were heard equally in both lungs. Anesthesia was maintained with halothane (1.0 per cent) and nitrous oxide (70 per cent) in oxygen, and muscle relaxation was achieved with a succinylcholine infusion. Ventilation was controlled manually.

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Anesthesia and operation proceeded uneventfully for approximately 45 min, after which an increased inspiratory pressure was suddenly needed to ventilate the patient's lungs. In the next 10 min, the peak airway pressure increased from 30 torr to more than 50 torr. Breath sounds from both sides of the lungs were still equal, but diminished. The ventilatory pattern showed that both the inspiratory and expiratory phases were prolonged more than 5 sec. At this time, the patient attempted to breathe spontaneously, but only minimal and inadequate gas exchange resulted. The endotracheal-tube cuff was deflated and the tube was gradually withdrawn until the cuff was visible just below the skin margin. Ventilation or inspiratory pressure did not change. Ventilation immediately improved after the endotracheal tube was completely removed and a cuffed Shiley® tracheostomy tube was inserted. The chest wall then expanded and normal breath sounds were heard in each lung. Anesthesia and operation continued without further incident.

Later, inspection revealed a bubble 3 cm long located 9 cm from the distal end of the anode tube. The bubble almost completely obstructed the tube lumen—only a rim of light could be seen when looking through the tube (fig. 1). Inflation of the cuff did not affect this bubble and its size was unaffected by the air within the tube cuff or pilot tube. The bubble had almost completely disappeared after an hour, but a rubber fold protruded into the lumen of the tube where the bubble had been. We attached the tube to an anesthesia machine and directed nitrous oxide (70 per cent) in oxygen through the lumen at a rate of 4 l/min. After 45 min, a whistling sound began, the reservoir bag distended, and the pressure gauge on the circle apparatus registered 40 torr. Inspection showed that the bubble had reappeared and, again, it disappeared gradually after exposure to room air (fig. 2). Delivery of halothane (5 per cent) and oxygen through the lumen of the tube did not result in bubble formation. Longitudinal dissection of the tube and spiral wire and removal of wire segments demonstrated that the bubble space was connected to the space within the tube wall created by the wire coil.



FIG. 1. Roentgenogram of the endotracheal tube filled with Renografin-76 solution shows the intraluminal bubble that occurred after 45 min exposure to nitrous oxide.

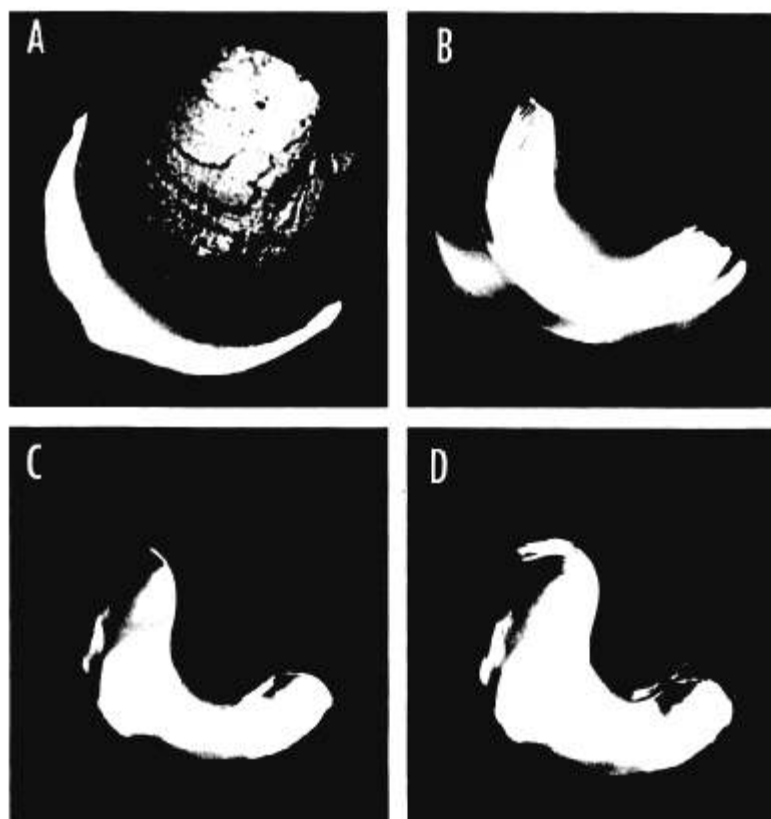


FIG. 2. Photographs taken from the distal end of the endotracheal tube show the intraluminal obstruction that occurred after exposure to nitrous oxide (A), and 30 min (B), 60 min (C), and 16 hours (D) after exposure to room air. The narrow rim of visible light (elliptical area, lower left) shown in A enlarged as the bubble (upper right) decreased in size (B). The residual bubble and folds of tube wall are evident in C and D.

### DISCUSSION

Two problems coincided in this case. First, nitrous oxide has been demonstrated to diffuse into the endotracheal-tube cuff and increase its size and pressure.<sup>1</sup> Second, layers of wire-imbedded endotracheal tubes formed by a dipping process (laminated) can separate and blister. The development of these hidden air spaces may be encouraged by steam cleaning or the use of ethylene oxide sterilization, which uses a decompression cycle.<sup>2</sup> In our hospital, tubes of this type are steam-cleaned. Moreover, the complication is difficult to recognize because the air bubble enlarges slowly and because the tube must be inspected meticulously before anesthesia is induced to detect this defect. However, careful examination of both the internal and external surfaces of the endotracheal tube before its use and rejection of tubes with areas of light color, wall separation, or bubbles will prevent the complication.

Obstruction of latex, wire-imbedded endotracheal tubes by a mechanical defect that allows gas within the tube cuff to enter and enlarge the space between layers of the latex tube has been reported.<sup>3</sup> However, in the present study, the bubble was not affected by gas within the cuff and pilot tube. In this case, nitrous oxide amplified the size of the air bubble in

the endotracheal tube, the occlusion of which caused airway obstruction. While this mechanism was not previously reported as an explanation for endotracheal tube obstruction, Burns described an identical incident in 1956 in a brief note in the *British Medical Journal*.<sup>4</sup> Burns did not attribute the intraluminal obstruction in his case to nitrous oxide, but rather to trichloroethylene, which he demonstrated to cause swelling and distortion of the inner lining of the latex endotracheal tube. We observed this phenomenon when we applied liquid halothane to the internal surface of our tube. We credit Burns for what we believe is the first description of the bubble-amplification effect of nitrous oxide.

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