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Percutaneous Transtracheal High-frequency Jet Ventilation as an Aid to Fiberoptic Intubation

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The advent of fiberoptic laryngoscopy has revolutionized the management of difficult airways. A variety of oral and nasal airways and masks have been devised to permit fiberoptic laryngoscopic intubation after general anesthesia has been induced,[1,2] but, with all these devices, the anesthesiologist must simultaneously ventilate by mask while attempting fiberoptic laryngoscopy. We report four cases in which transtracheal high-frequency jet ventilation (HFJV) proved to be a valuable aid to fiberoptic endotracheal intubation.

In our series, all patients had a 14-gauge catheter inserted percutaneously through the cricothyroid membrane under local anesthesia with lidocaine using the technique described by Spoerel.[3] Catheter position within the trachea was confirmed by free aspiration of air. High-frequency jet ventilation was instituted with a Systems MK 800® ventilator (Acutronic Medical Systems). Observation of chest wall and abdominal movement, as well as audible expiration in cycle with the jet, were used to confirm ventilation. Transcutaneous oxygen saturation was continuously monitored with a pulse oximeter (Nellcor®). Adequacy of carbon dioxide elimination was assessed by measurement of end-tidal CO_2 by mass spectrometry (Perkin Elmer) recorded immediately following endotracheal tube placement and the institution of conventional ventilation.

REPORT OF FOUR CASES

Case 1. A 36-yr-old woman underwent modified radical mastectomy with general anesthesia given *via* a face mask, because tracheal intubation under direct laryngoscopy was unsuccessful. Abdominal flap reconstruction was subsequently scheduled, and intubation was again unsuccessful, despite the attempts of five attending anesthesiologists using a variety of blades, tube sizes, and muscle relaxants, as well as blind nasal intubation during spontaneous ventilation with halothane/O_2. The procedure was postponed owing to airway edema, gastric distension, and difficulty maintaining ventilation by a mask. Surgery was rescheduled 4 days later, at which time tracheal intubation under sedation and topical analgesia was attempted. Fiberoptic bronchoscopy could not be performed because of the patient's continued lingual movements and poor cooperation. The patient refused further intubation attempts, and spinal anesthesia was provided. She returned 18 months later for combined mastectomy and reconstruction of the left breast. Possible anesthetic techniques were explored in detail with the patient, and she agreed to general anesthesia with HFJV.

Following premedication with morphine and hydroxyzine, monitors included a precordial stethoscope, blood pressure cuff, electrocardiogram (ECG), and pulse oximeter. Vital signs were stable and oxygen saturation remained above 98% throughout the procedure. A 14-gauge catheter was inserted percutaneously through the cricothyroid membrane under local anesthesia. HFJV was started with 100% O_2 at 30 psi, 100 cycles per minute, 1:2 inspiratory:expiratory (I:E) ratio, and general anesthesia was induced with fentanyl, 350 μg; diazepam, 10 mg; droperidol, 2.5 mg iv; and succinylcholine by infusion. Oral fiberoptic bronchoscopy was performed, which demonstrated an anterior larynx and a supraglottic tissue band extending from the left lateral pharyngeal wall to the left arytenoid. The transtracheal catheter was easily visualized, and aided identification of the trachea. An 8-mm Portex endotracheal tube was advanced over the bronchoscope and into the trachea. HFJV was then replaced with conventional positive-pressure ventilation, and nitrous oxide and isoflurane were added. After surgery, the patient was taken to the recovery room, where the trachea was extubated and the transtracheal catheter removed without incident. The patient recovered uneventfully. Tracheostomy was avoided to reduce the likelihood of wound contamination and to promote a cosmetic result.

Case 2. A 75-yr-old woman was scheduled for breast biopsy. She had a history of hypertension, myocardial infarction, asthma, obesity, and parathyroidectomy. Her medications included diuretics and levothyroxine. Arterial blood pressure was 120/80 mmHg, and respiratory rate was 14 breaths/min. There was a midline trachea, parathyroidectomy scar, and a white lesion was present at the base of the tongue. After breathing oxygen, anesthesia was induced with fentanyl, 50 μg, and etomidate, 20 mg iv. Despite vigorous efforts, ventilation *via* a mask could not be accomplished, and gastric distension was noted. After the return of spontaneous ventilation, the trachea was intubated, but visualization of the larynx was poor because of its anterior location, a large tongue, and narrow laryngeal aperture. After intubation, anesthesia was continued with isoflurane/N_2O/O_2. Postoperatively, she had right mandibular tenderness and recalled the intubation. She was subsequently scheduled for axillary node dissection and biopsy of the tongue. Anesthetic options were explained, and the patient agreed to general anesthesia with HFJV. The patient was sedated and taken to the operating room, where a 14-gauge transtracheal catheter was inserted through the cricothyroid membrane under local anesthesia, and HFJV was begun. General anesthesia was induced with thiopental and

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maintained with fentanyl iv and inhalation of N_2O and O_2. Fiberoptic bronchoscopy was performed, and the trachea visualized. The transtracheal catheter was easily identified. A 7-mm nasotracheal tube was advanced into the trachea. Conventional ventilation was instituted instead of HFJV to allow the use of isoflurane. After the surgical procedures, the trachea was extubated in the operating room, and the patient recovered uneventfully. She had no recall of the intubation.

Case 3. A 17-yr-old boy was scheduled for placement of a ventriculo-peritoneal shunt. He had a diagnosis of osteogenesis imperfecta with multiple anomalies including facial deformities, high arched palate, hyperplastic gingiva, limited neck mobility, basilar cranial hyperostosis with partial cranial nerve compression, profound hearing loss, and clubbed fingers and toes. A 14-gauge transtracheal catheter was placed through the cricothyroid membrane and HFJV was administered. Once ventilation had been demonstrated, general anesthesia was induced with thiopental iv and maintained with fentanyl iv and inhalation of N_2O and O_2. Oral fiberoptic intubation was performed with difficulty. The trachea was visualized and the transtracheal catheter was identified. A 7-mm armoured endotracheal tube was advanced into the trachea and conventional ventilation begun with the addition of isoflurane. After the shunt was completed, the trachea was extubated uneventfully in the operating room.

Case 4. A 16-yr-old boy was admitted with hemifacial microsomia, aseptic necrosis of the right temporomandibular joint and ramus, lack of development of the chin, and left inferior border of the mandible. He was scheduled for total facial reconstruction. Because of a 1-cm opening between maxillary and mandibular incisors, the patient underwent an interpositional gap arthroplasty, which created a 5-cm opening. Because of previous experience with intubation while awake, he was very anxious. A nasotracheal intubation was planned to facilitate surgery. After anesthesia was induced with thiopental iv and ease of ventilation by mask was verified, succinylcholine was administered iv and conventional laryngoscopy was performed. The laryngeal structures were not visualized. A 14-gauge catheter was introduced through the cricothyroid membrane, and HFJV was begun at a driving pressure of 20 psi, inspiratory time of 30%, and frequency of 100 cycles per min. Anesthesia was maintained with midazolam, fentanyl iv, and an infusion of succinylcholine. Nasotracheal intubation was then accomplished with fiberoptic bronchoscopy. After the nasotracheal tube had been secured, HFJV was discontinued, the catheter removed, and conventional ventilation begun. The remainder of the procedure was uneventful.

Discussion

While fiberoptic intubation may be performed using topical anesthesia, potentially toxic doses of local anesthetic may be necessary for patient comfort.[4] The use of sedation may be limited by increased intracranial pressure, as in case 3, and may lead to respiratory insufficiency or aspiration of gastric contents in patients who have inaccessible airways. Even the most careful use of topical anesthesia and heavy sedation may prove inadequate, as in case 1. Lack of patient cooperation may further complicate a difficult tracheal intubation. General anesthesia given *via* a mask may overcome suboptimal cooperation, but may require the skills of two anesthesiologists—one to maintain mask ventilation, and another to perform fiberoptic laryngoscopy. Gastric distension may be created. Also, the anatomy may be obscured by the mask and airway. Placement of the transtracheal catheter is safe and well tolerated; a similar technique is used for transtracheal aspiration in the diagnosis of pneumonia with few complications (bleeding, infection, or fistula), even in critically ill patients.[5,6] In our series of patients, arterial blood pressure and heart rate remained within 20% of baseline, and oxygen saturation was acceptable throughout the procedure. Immediately after placement of the endotracheal tube and institution of standard mechanical ventilation, end-tidal CO_2 was measured. No evidence of hypercarbia was detected.

Alternative airway management techniques, including tracheostomy, awake oral intubation, blind nasal intubation, and percutaneous ventilation with the Sanders hand-held jet, may be utilized.[7] Fiberoptic intubation following induction of general anesthesia by mask may be employed. This may be facilitated by use of the Patil-Syracuse® mask (Anesthesia Associates, Inc.), which has a port for admission of a fiberscope and endotracheal tube.[2] Retrograde intubation utilizing a guide wire or catheter inserted transtracheally and extracted from the mouth has been suggested as a guide for blind intubation and as an aid for fiberscopic intubation by placing the catheter through the suction port of the fiberscope.[8] These techniques may prove to be uncomfortable, unreliable, or inadvisable due to simultaneous medical conditions.[9,10] Our technique should be included in the anesthesiologist's armamentarium.

Complications of this technique did not occur in our series, but anesthesiologists should be aware of potential risk before utilizing our technique. These risks include misplacement of the catheter leading to hemorrhage, laryngeal injury, and subcutaneous or mediastinal emphysema.[3,5,11]† High-frequency ventilation through a properly placed catheter carries the risk of barotrauma leading to pneumothorax, should outflow obstruction prevent passive deflation between breaths.† Adequacy of oxygenation should be monitored throughout the procedure.

The use of transtracheal HFJV before fiberoptic laryngoscopy provides unobstructed access to the mouth and nose,[11,12] and reduces the likelihood of gastric distension and aspiration.[13,14] The visualization of the transtracheal catheter provides an unmistakable landmark for even inexperienced endoscopists. There is an immediately available means of ventilation should airway difficulty recur after extubation. Patient acceptance of the procedure has been excellent.

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Pharmacokinetics and Cardiovascular Effects of Bupivacaine during Epidural Anesthesia in Children with Duchenne Muscular Dystrophy

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Duchenne muscular dystrophy (DMD) is the most common muscular dystrophy. Children with this dystrophy often need orthopedic surgery to either extend their walking capacity or to facilitate nursing care. General anesthesia is associated with an increased risk in such patients, owing to poor cardiovascular and respiratory function and altered sensitivity to some anesthetics.[1–4] Although regional anesthesia is an appropriate choice for certain operations, the pharmacokinetics of local anesthetics are unknown in such patients. Some differences could be expected owing to the particular distribution of both fat and muscle compartments in these patients. Thus, this study was undertaken to assess the pharmacokinetics of bupivacaine following lumbar epidural injection in children with DMD.

MATERIALS AND METHODS

The study was carried out in five children with DMD scheduled for multiple tenotomies. Characteristics of the patients are shown in table 1. The index of obesity (OI) was calculated for each child using the following formula, especially designed for scoliotic patients:[5,6]

$$OI = \frac{WT}{S^3 \times 12.67}^{\circledR},$$

where weight (WT) is expressed in kg and S is the armspan expressed in meters. The normal value is 1. In all patients, preoperative evaluation revealed severe pulmonary impairment with a marked reduction in both vital capacity and peak-flow values, when compared to normal predicted values for age. Systolic time intervals (STI) measured according to the criteria of Lewis *et al.*[7] were increased in two out of the five children (normal values 0.32 ± 0.03). The ejection fraction (EF) was measured by isotopic scintigraphy in three children, including one for whom the STI was prolonged, and was within the normal range (65 ± 5%). Both indexes have proved to be sensitive indicators of cardiac dysfunction in such patients.[8,9]

The children included in the present study were not premedicated. Informed consent was obtained from the parents during the preoperative visit. The study was approved by the Ethics Committee of the Hospital. General anesthesia was induced by Flunitrazepam (30 μg/kg) iv. Their tracheas were intubated, and ventilation controlled to maintain end-tidal CO_2 within normal limits (4–5 kPa). Epidural anesthesia was performed at a

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