Jet ventilation in a case of tracheal obstruction secondary to a retrosternal goitre

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Intermittent jet ventilation was used during anaesthesia in a 66-yr-old woman who had severe tracheal narrowing secondary to compression by a retrosternal goitre. The trachea was intubated by a small-bore tube, which was placed above the site of narrowing. An injector was connected to the proximal end of the tracheal tube on one side and to the anaesthesia circuit on the other. Intermittent jets of 66% nitrous oxide in oxygen via the injector resulted in adequate oxygenation and carbon dioxide elimination. Arterial blood gas analysis during jet ventilation showed PaO_2 150 mmHg, $PaCO_2$ 35 mmHg and pH 7.4. It is concluded that low-frequency jet ventilation may provide adequate oxygenation and carbon dioxide elimination in the presence of tracheal narrowing.

On a utilisé la ventilation intermittente à jet pendant l'anesthésie d'une femme de 66 ans souffrant d'un rétrécissement trachéal serré causé par un goitre rétrosternal. La trachée est intubée d'abord avec un tube de petit calibre placé au dessus du rétrécissement. Un injecteur est branché sur l'extrémité proximale du tube endotrachéal d'un côté et sur le circuit anesthésique de l'autre. Des jets intermittents de protoxyde d'azote 66% avec oxygène produisent une oxygénation et une élimination du gaz carbonique adéquates. L'analyse des gaz artériels montre une PaO_2 de 150 mmHg, une $PaCO_2$ de 35 mmHg et un pH de 7,4. Nous concluons que la ventilation par jet à basse fréquence peut procurer une oxygénation et une élimination du gaz carbonique adéquates en présence d'un rétrécissement serré de la trachée.

Key words
AIRWAY: obstruction;
COMPLICATIONS: goitre;
EQUIPMENT: ventilator, jet;
LUNG: trachea.

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Intermittent jets of oxygen have been previously used during anaesthesia for ventilating the lungs of patients with tracheal stenosis[1] or tracheal tumour.[2] The present case report shows that jet ventilation is also advantageous in the presence of severe tracheal obstruction secondary to a retrosternal goitre.

Case report

The patient was a 66-yr-old woman who suffered from frequent and progressive episodes of dyspnoea and inspiratory as well as expiratory stridor. Arterial blood gas analysis while the patient was breathing spontaneously face mask oxygen showed: PaO_2 73 mmHg, PCO_2 54 mmHg, pH 7.30, and SO_2 95%. Fibreoptic bronchoscopy under topical analgesia did not show any supraglottic or glottic lesions, but revealed severe fixed tracheal narrowing above the level of the carina. The bronchoscope could not bypass the lesion, and the cross-sectional diameter at the narrowest point of the trachea was estimated to be about 5 mm. The CT scan revealed a soft tissue mass in the anterior mediastinum extending from the base of neck, compressing and displacing the trachea to the right. The heart was normal, and both lungs were clear without any evidence suggestive of pulmonary oedema (Figure 1).

The patient was premedicated with atropine 0.6 mg *im*. In the operating room, the patient was continuously monitored by ECG and pulse oximetry. Also, an arterial line was used for continuous blood pressure monitoring and for blood gas sampling. Awake laryngoscopy was performed under topical anaesthesia. The trachea was intubated with a cuffed orotracheal tube (ID 6 mm), which was kept below the vocal cords and above the site of tracheal narrowing. Following tracheal intubation, inhalational anaesthesia was induced by spontaneous breathing of oxygen-halothane. Manual controlled ventilation was difficult. An injector was then adapted between the tube connector and the anaesthesia carbon dioxide absorption circuit (Figure 2). Intermittent oxygen jet ventilation, while keeping the scavenger valve open, resulted in adequate chest inflations.

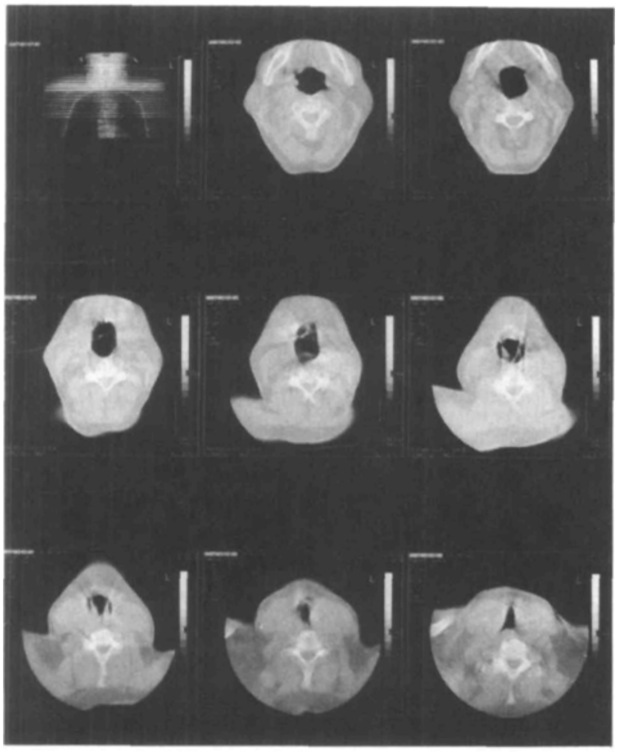

FIGURE 1 CT scan showing soft tissue swelling in the base of neck and anterior mediastinum mainly on the left side, compressing and displacing the trachea to the right. Maximal compression of the trachea is intrathoracic just above the carina.

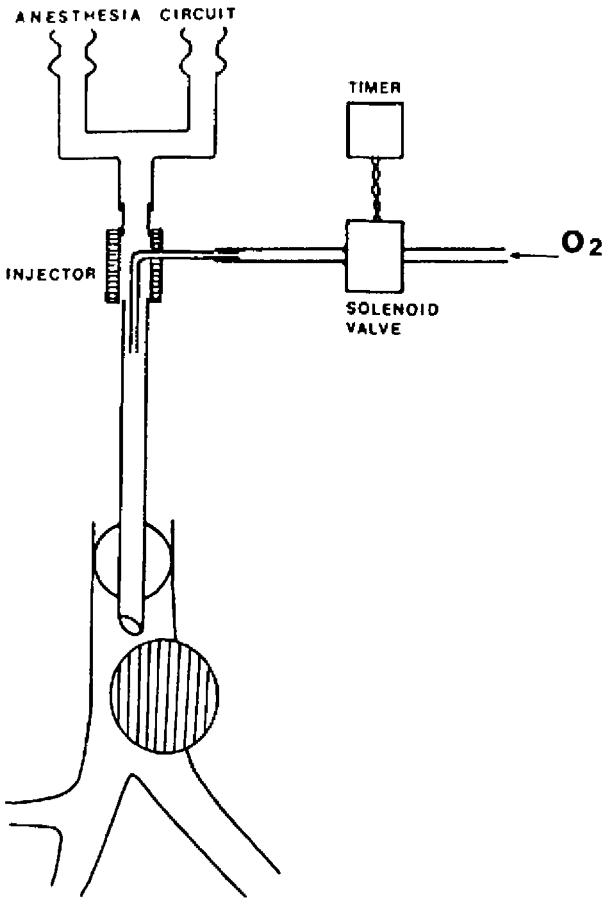

FIGURE 2 Diagram of the system used for jet ventilation. The injector is connected to the tracheal tube on one side and to the anaesthesia circuit on the other. The injector is driven by intermittent jets of oxygen or nitrous oxide:oxygen jets that are automatically interrupted by an electronic timer controlling a solenoid valve.

Controlled ventilation was achieved by intermittent oxygen jets of a pressure of 40–60 PSI, which were delivered via the injector at a rate of 12 per minute (inspiratory time one second: expiratory time four seconds). Arterial blood gas analysis showed PaO_2 450 mmHg, PCO_2 36 mmHg, pH 7.4 and SO_2 100%. Thus, it was considered safe to induce neuromuscular block with vecuronium 0.1 $mg \cdot kg^{-1}$. Also the oxygen jets were replaced by intermittent jets of 66% N_2O in oxygen which were delivered to the injector from a nitrous oxide:oxygen blender. A similar gas mixture (nitrous oxide 2 $L \cdot min^{-1}$:oxygen 1 $L \cdot min^{-1}$) was delivered by the anaesthesia circuit. Repeating arterial blood gas analysis showed: PaO_2 150 mmHg, $PaCO_2$ 35 mmHg, pH 7.4 and SO_2 99%.

The patient was positioned supine with the neck extended by a pillow under the shoulders. A low horizontal neck incision was made, and a huge retrosternal nodular mass (15 × 7 cm) could be dissected and enucleated via the cervical collar incision, without the need for a vertical sternal split. Pathology showed a hyperplastic nonmalignant multimodular goitre. Following enucleation of the tumour, manual ventilation was easy, and the tracheal tube could be easily moved down the trachea without meeting any resistance. At the end of surgery, neuromuscular blockade was reversed with a mixture of atropine and neostigmine, and the trachea was extubated. The patient breathed spontaneously without any signs of respiratory obstruction. Arterial gas analysis while breathing room air showed: PaO_2 90 mmHg, $PaCO_2$ 44 mmHg and pH 7.4.

Discussion

Ventilation in patients with tracheal obstruction secondary to a tracheal lesion or to compression by a retrosternal mass can create serious airway difficulty.[3] Generally, symptoms of airway obstruction become clinically evident when the cross-sectional diameter of the trachea is narrowed to 5–6 mm.[4] Our patient had signs and symptoms of respiratory distress, hypoxaemia and hypercarbia; the cross-sectional diameter at the narrowest part of the trachea was about 5 mm, as estimated by fibreoptic bronchoscopy.

The anaesthetic managment of a patient with tracheal narrowing is a challenge to the anaesthetist, who must achieve adequate ventilation in the face of marked inspiratory and expiratory resistance. Careful preoperative assessment of the degree and site of tracheal obstruction must be done. In our patient, assessment was carried out preoperatively by CT scan, fibreoptic bronchoscopy and blood gas analysis.

The anaesthetic plan must follow a step-by-step algorithm in order to provide safety and minimize serious hypoxaemia. The patient was monitored intraoperatively by contiuous ECG and pulse oximetry. Because of the severe tracheal narrowing, we initiated our anaesthetic management by awake tracheal intubation using a relatively small-bore tracheal tube. The distal end of the tube was positioned below the vocal cords and above the site of tracheal narrowing. Attempting to pass a small-bore tracheal tube beyond the lesion can be hazardous, and may be complicated by oedema, bleeding or dislodging of tissue resulting in further airway obstruction. However, the tube may be pushed down beyond the site of narrowing whenever serious airway obstruction complicates induction of anaesthesia or surgical manipulations.

Following awake tracheal intubation, general anaesthesia was induced by spontaneous breathing of halothane in 100% oxygen. Spontaneous breathing is safer than controlled ventilation in patients with tracheal narrowing. Controlled ventilation may critically reduce already narrowed airway, and cause anaesthetic gases flowing through narrow airways to undergo turbulance and impair gas exchange considerably.[5] Thus, the use of muscle relaxants can be hazardous in patients with tracheal narrowing, and should only be administered after ensuring adequate ventilation. In our patient, manual controlled ventilation was met with marked resistance, and hence a conventional volumetric anaesthesia ventilator was not used. In contrast, intermittent jet ventilation achieved adequate chest inflation and resulted in adequate oxygenation and carbon dioxide elimination.

Barotrauma with resultant pneumothorax can complicate both transtracheal and translaryngeal jet ventilation.[6-8] The risk of penumothorax is much higher in the presence of tracheal obstruction because gas cannot escape readily from the lungs; air trapping may follow if the effective tracheal diameter is about 4–4.5 mm.[6] In a patient with a critically small effective tracheal diameter, the use of low-frequency jet ventilation and adjustment of the inspiratory:expiratory ratio at about 1:4 results in the delivery of an adequate tidal volume, and ensures a long exhalation time which minimizes the possibility of air trapping and lung hyperinflation.

Intermittent oxygen jets have been used initially to ventilate patients undergoing bronchoscopy. Sanders[9] adapted a Venturi injector attachment to the unoccluded head of the bronchoscope. The jet delivered via the injector entrains a high flow of room air, which provides enough pressure and volume to ventilate the lungs. Jet ventilation has been shown to be effective in the presence of tracheal stenosis,[1] tracheal tumour,[2] or airway disruptions.[10] The present report shows that jet ventilation via a small-bore tracheal tube can also achieve adequate oxygenation and carbon dioxide elimination in patients having severe tracheal compression by a retrosternal goitre.

The high pressure jets which are delivered above the tracheal lesion can produce an effective pressure gradient across the narrow segment of the trachea, whether tracheal narrowing is due to tracheal stenosis, tumour or secondary to external compression by a retrosternal mass. Also, the jet can create a Venturi effect which results in further gas entrainment from the anaesthesia circuit, and hence provides the presure and volume necessary for efficient ventilation in face of the tracheal narrowing.

In conclusion, the present report shows, in a patient with severe tracheal narrowing secondary to a retrosternal goitre, that low-frequency jet ventilation can provide adequate oxygenation and carbon dioxide elimination in the presence of tracheal narrowing. Adjustment of the inspiratory:expiratory ratio to about 1:4 ensures a long exhalation time which minimizes the possibility of air trapping and lung hyperinflation.

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