Transtracheal jet ventilation

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Abstract

Transtracheal jet ventilation is a technique for ventilation of apnoeic lungs. This article outlines the indications, equipment required, insertion technique and complications of transtracheal jet ventilation. It can be used electively to aid management of the difficult airway and for laryngeal surgery. It also has a vital role in the management of the 'can't intubate — can't ventilate' scenario. Death and hypoxic brain damage under anaesthesia are fortunately rare, but most commonly occur as a result of problems with tracheal intubation. No patient should suffer hypoxic brain damage without an attempt at transtracheal ventilation being made.

Keywords Difficult airway; failed intubation; jet ventilation; Ravussin needle; transtracheal

Royal College of Anaesthetists CPD matrix: 3A02

Learning objectives

After reading this article, you should understand the:
- physiology and principles of physics of jet ventilation
- placement of jet ventilation cannula and relevant anatomy
- complications that may happen with the use of jet ventilation

Transtracheal jet ventilation is a form of ventilation via a catheter placed in the trachea bypassing the glottis and supraglottis. The catheter is then used to ventilate apnoeic lungs in emergency or elective situations.

Death and hypoxic brain damage under anaesthesia are rare, but most commonly occur as a result of problems with tracheal intubation. The Difficult Airway Society has produced guidelines[1] for the management of the 'can't intubate — can't ventilate' scenario that advocate the use of transtracheal jet ventilation. No patient should suffer hypoxic brain damage without an attempt at transtracheal ventilation being made.

History

The history of percutaneous transtracheal jet ventilation (PTJV) dates back to the 1950s when Jacoby et al. and Reed et al. published their work. Sanders et al. described jet ventilation in the 1960s followed by Spoerel in 1971 who described the transtracheal jet ventilation in his series of patients. In these papers the technique was advocated for elective surgical procedures as well as an alternative in difficult airway management in conjunction with laryngoscopy.[2] Layman et al. reported a series of 60 patients with difficult airways in 1983, and in 1985 Ravussin designed a dedicated transtracheal catheter that was later included in the Difficult Airway Society guidelines for managing difficult airways in 1998. Initially the technique was not looked at favourably due to the reported high complication rates. However, following more studies in 1987 covering both routine and emergency use of the PTJV with good outcomes, it gained popularity.[3] Another multicentre study was conducted in 2001 involving 643 patients and reporting the efficacy and complications associated with transtracheal jet ventilation.[4] In 2005 a series of 43 procedures carried out was published which promoted PTJV.[5]

Physiology

High-frequency jet ventilation (HFJV) involves tidal ventilation (TV) lower than the dead space; therefore the equation

$$\mathrm{t}_{V_A} = f \times (V_T - V_D)$$

cannot be used to explain the mechanism of gas exchange and alveolar ventilation. Some bulk flow may be possible in the alveoli close to the conducting airways but does not account for adequate ventilation and effective gas exchange.

Other mechanisms involved include laminar flow in the smaller airways where the Reynolds number is low and therefore result in a parabolic airflow, that is the centre of the airflow has the highest velocity. This difference in velocities is amplified with the jet ventilation and results in a net flow of gas moving inwards at the centre of the airway, whereas that around its margins tends to move out of the lungs.

Taylor-type dispersion and an interaction between axial parabolic velocity and radial concentration gradient explains further mixing of gases in smaller airways and in larger airways with turbulent flow eddy currents in combination with the bulk flow result in a similar radial mixing effect.[6]

Pendelluft or collateral ventilation is a consequence of the variable time constants of the alveoli and is seen more obviously in high-frequency breaths and facilitated by the higher mean airway pressures seen in HFJV leading to extensive Pendelluft with recirculation of gas between regions. Smaller volumes of gases reach more respiratory units as compared to the tidal volumes in conventional ventilation.[6]

It is effectively a time-cycled, pressure-limited ventilation and a decrease in compliance of the system results in a reduction in minute ventilation. The driving pressure rather than the frequency of ventilation determines CO_2 elimination.

Indications

Emergency

Transtracheal jet ventilation is preferable to tracheostomy in the 'can't intubate — can't ventilate' scenario as it is quick to perform and has a lower complication rate.[7]

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Elective

Percutaneous transtracheal jet ventilation has several advantages in managing difficult airways, for example securing a route for oxygenation preinduction; eliminating the need for laryngoscopy to secure the airway; providing an unobstructed view of the larynx; and the potential to leave the catheter in place postoperatively in the event that the patient needs further respiratory support. It can be used electively in patients when difficult ventilation is anticipated,[3] such as obstructing upper airway lesions, and is a useful alternative to awake tracheostomy. Insertion is well tolerated in the awake patient.

It is a useful aid for intubation in cases where the larynx is obscured by swelling or tumour.[8] Intubation is guided by visualization of expiratory gas bubbles in the pharynx.

Transtracheal jet ventilation is routinely used for airway management for surgery on the larynx or trachea, including laser surgery.

Equipment

There are several types of jet ventilation cannula. The Ravussin jet ventilation catheter (VBM Medizintechnik, Sulz, Germany) is produced in three sizes: 13G for use in adult patients and 14G and 18G for paediatric patients. Other types available include the emergency transtracheal airway catheter (Cook, Bloomington, IN, USA). The ideal cannula should be kink resistant and easy to secure to the neck.

The Teflon-made VBM cannula (Figure 1) has some resistance to kinking. It has a curved shaft and an angled connector that sits flush with the skin and is easily secured with the Velcro strap provided. It has two connectors: a 15 mm diameter ISO (International Organization for Standardization) male connector, which allows connection with a standard anaesthetic system for oxygen insufflation, and a Luer lock connector for high-pressure jet ventilation.

There are several methods for oxygenation through the catheter.

- *Anaesthetic circuit*, which will enable apnoeic oxygenation. Many other methods have been described for connection to a low-pressure oxygen outlet; Cook produces oxygen tubing designed for connection to a transtracheal catheter.
- *Sanders injector* (Figure 2) connects to a 4 bar oxygen source to enable jet ventilation. There is a variable outlet pressure version, the manujet made by VBM, which increases safety. Driving pressure can be adjusted between 0 and 4 bar.
- *Jet ventilator* (Figure 3), for example the Mistral (Acutronic Medical Systems, Hirzel, Switzerland) is a high-frequency ventilator and can ventilate at rates of 12—600, with a driving pressure of 0—4 bar and a variable inspiratory: expiratory (I:E) ratio. This ventilator also monitors pause pressure and will cut out if intratracheal pressure is above a set level (usually 10—30 mbar).

Figure 1 VBM transtracheal catheter.

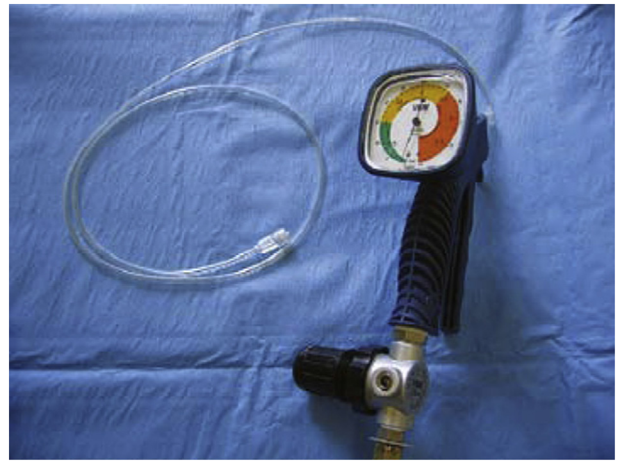

Figure 2 Sanders injector.

Equipment for transtracheal jet ventilation must be available on a difficult intubation trolley in all areas managing potentially difficult airways.

Technique

After opening the cannula on a sterile towel, draw 2.5 ml of saline in a 5 ml syringe. Prepare a three-way tap with a short extension, and attach capnograph tubing on the side arm. Checking that the necessary apparatus is available and in working order is essential.

Optimal patient position is supine with the neck extended. This may be difficult to achieve in an awake patient with respiratory distress. Cannulation is still possible in a patient with a flexed neck who is sitting up. Identifying the anatomy, marking the position of the thyroid cartilage, the cricoid cartilage and the midline is useful (Figure 4). Aseptic technique is essential, including cleaning the skin with 2% chlorhexidine and wearing sterile gloves. In an awake patient, 2% lidocaine used subcutaneously at the insertion site is recommended.

Figure 3 Mistral jet ventilator.

