Jet ventilation for maxillofacial and laryngotracheal anaesthesia: a narrative review

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Background and Objective: Jet ventilation is a commonly employed technique during oral and maxillofacial surgery and has been used for several decades. It allows positive pressure ventilation via a narrow orifice, which can be delivered via the supraglottic, subglottic or transtracheal route. Moreover, it can be provided using high- or low-frequency jets and using either an automated or manual device. Whilst it has the benefit of aiding a motionless surgical field it does not come without the adverse effects of hypercapnia and other potential complications. This article aims to review the current evidence and guidance on the uses of jet ventilation in maxillofacial and laryngotracheal anaesthesia.

Methods: A literature search was conducted in July 2023 to identify relevant articles about jet ventilation. The following databases were used: Embase, Medline, PubMed and Google Scholar and articles published in English prior to July 2023 were included.

Key Content and Findings: Jet ventilation is a safe, operational, and appropriate technique for patients undergoing maxillofacial and laryngotracheal surgeries. It is advantageous as it provides a motionless surgical field whilst maintaining oxygenation and there are a variety of effective catheters, cannulas, and ventilators to suit a variety of scenarios.

Conclusions: This article gives an overview of the different modalities of jet ventilation available, their uses, their physiology, technical aspects, and recommendations for the use of jet ventilation. In addition, it gives an insight into the expansion of jet ventilation use across other specialities. Future recommendations include national standardised operating procedures and the continued investment and multidisciplinary participation in jet ventilation training for all anaesthetists for both the difficult and elective airway.

Keywords: Jet ventilation; high-frequency; low-frequency; laryngotracheal surgery; maxillofacial surgery

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Introduction

Jet ventilation is a commonly used modality for the oxygenation of patients undergoing maxillofacial and laryngotracheal surgery. It is a highly versatile way of providing oxygenation, enabling gas delivery at multiple points along the airway. This includes but is not limited to alongside bronchoscopes, supraglotically, subglotically via catheters or transtracheal via percutaneous cannulas.

Jet ventilation is defined as the use of a high-pressure air source pneumatically cut or electronically controlled to

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generate a tidal volume which is applied to the patient (1). There is entrainment of gases possible at the jet nozzle and expiration is dependent on passive lung and chest wall recoil. Jet ventilation can be high or low frequency.

The use of ventilating bronchoscopes also played a role in the evolution of jet ventilation during shared airway surgery. This was first described by Douglas Saunders, who designed a connector to the rigid bronchoscope which allowed the delivery of oxygen at jet pressures of 3 bar via a 0.035-inch diameter nozzle (1) This technique allows the use of a hand-held operated valve to inject short bursts of high-pressure gas via a nozzle connected to a 100% oxygen and a pressure limiting valve. This overcame the prior need to pause surgery and remove the surgical instruments to oxygenate the patient instead of providing continuous oxygenation; pauses provided passive expiration.

The advent of jet ventilation dates to the 1970s when Klain and Smith (2) described the experimental use of intermittent ventilation via a fluidic logic-controlled oxygen jet ventilator at rates of 20–200/min in dogs through a transtracheal catheter. This allowed surgical access to the airway via an open, rigid bronchoscope with concurrent oxygenation via a separate tracheal cannula. Their results showed that intermittent high-pressure jet ventilation was able to maintain adequate oxygenation using ventilation rates of 200/min. It was later applied to patients undergoing laryngoscopy under general anaesthesia with the benefit of an undisturbed surgical field whilst allowing adequate oxygenation at a ventilatory rate of 100/min and driving pressure (DP) of 2.2–3.6 bar (3).

Jet ventilation has since become a commonly employed technique for patients undergoing microlaryngoscopy, laryngeal surgery and cervicofacial cancer pan endoscopies. It has proved beneficial by improving surgical conditions and providing a means of ongoing oxygenation should an airway compromise or emergency occur. It may also be required in cases of severe maxillofacial trauma when oral or nasal intubation is not feasible (4).

However, a UK-based national survey conducted in 2006 showed that only 67% of departments offered a form of jet ventilation (5). At this time jet ventilation was part of the Difficult Airway Society (DAS) 'Intubation Guidelines-Cannot Intubate, Cannot Ventilate' algorithms (6). In the updated 2015 guidance from DAS (7) jet ventilation has been removed. No similar surveys have been repeated since 2006 but given jet ventilation is no longer recommended as the final lifesaving step in front of neck access, jet ventilation is restricted to Ear Nose and Throat and Oral Maxillo-Facial centres in the UK.

Currently, there are no consensus agreements on the mode of oxygenation, transtracheal or subglottic catheter or cricothyroid cannula nor the mode of ventilation high or low frequency ventilation and the various pressure and time settings. As such, the aim of this article is to give an overview of the current evidence and uses of jet ventilation in maxillofacial and laryngotracheal anaesthesia from the available literature and guidance. We present this article in accordance with the Narrative Review reporting checklist (available at https://joma.amegroups.com/article/view/10.21037/joma-23-24/rc).

Methods

A literature search was conducted, and key published articles were identified using Embase, Ovid, PubMed and Google Scholar published in English up until July 2023. Papers not published in English, those with non-human subjects, paediatric patients (aged <18 years) and front-of-neck access in Intensive Care Units and pre-hospital were excluded. Published titles and abstracts were reviewed and those deemed clinically relevant were included (*Table 1*). This narrative review did not include a full critical appraisal of the literature.

Indications, advantages and disadvantages of jet ventilation

Jet ventilation can be used electively in the airway management of maxillofacial and laryngotracheal surgery. It can also be used in the emergency setting in a 'Can't intubate, Can't oxygenate' (CICO) airway scenario via a cricothyroid or transtracheal cannula. The high-flow oscillating component of jet ventilation is used in neonatal and paediatric critical care as a rescue ventilatory strategy in respiratory distress though it is normally administered in normal bore endotracheal tubes (ETTs). Further discussion on paediatric populations is beyond the scope of this review.

In the elective setting commonly encountered operations that benefit from a jet ventilation airway approach are: microlaryngoscopy procedures, laser airway ablations, tracheal dilatations, vocal cord surgery and cervicofacial cancer pan endoscopies. Emergency use of jet ventilation is more commonly encountered during maxillofacial surgery in cases such as severe trismus, infection or trauma requiring transtracheal ventilation.

As with all invasive techniques, it is not without issue.

Table 1 Search strategy

Items	Specification
Date of search	9/7/2023
Databases used	PubMed, Google Scholar, Ovid, Embase
Search terms	Jet ventilation, maxillofacial, high-frequency jet ventilation, high- frequency oscillation, low frequency jet ventilation, Tubeless anaesthesia, Jet ventilation complications, Jet ventilation maxillofacial, jet ventilation cricothyroidotomy
Timeframe	Prior to 9/7/2023
Inclusion and exclusion criteria	Inclusion: English language reviews, editorials, correspondence, trials, and case reports related to jet ventilation in adults
	Exclusion: non-English language reviews, paediatric patient populations, ICU jet ventilation
Selection process	First author O.D. independently reviewed the titles and abstracts based on the inclusion criteria

ICU, intensive care unit.

Table 2 Advantages and disadvantages of jet ventilation

Advantages of jet ventilation	Disadvantages of jet ventilation
Potential for tubeless field during laser surgery reducing the risk of airway fire	No protection against soiling of airway from surgical or gastric contents if jet catheter used alone
Jet catheters can be used through conventional endotracheal tubes or in isolation	Unable to measure airway pressures
Superimposed resumption of spontaneous respiration during emergence with catheter/cannula *in situ*	Unable to administer volatile gases so anaesthesia is total intravenous
Humidification achieved via Monsoon ventilator	Not all ventilators provide humidification
Open breathing system therefore no need for airtight connection between airway and breathing system	High driving pressures cause barotrauma if air not allowed to escape during passive exhalation resulting in pneumothorax, pneumothorax, pneumomediastinum, pneumoperitoneum, subcutaneous emphysema, pulmonary fibrosis
Less bronchial and mediastinal excursion compared to conventional ventilation	Risk of hypercapnia and inadequate gas exchange
Manipulation of airway during surgery by surgeon	Potential to dislodge catheter/cannula during surgery resulting in hypoxia, gastric distension and rupture and dysrhythmias

The advantages and disadvantages of jet ventilation for maxillofacial and laryngotracheal surgery are explored in *Table 2*.

Physiology of jet ventilation

Gas exchange and transport during jet ventilation is a complex process combining a multitude of mechanisms. Low-frequency jet ventilation (LFJV) is facilitated by the bulk flow of gases like awake spontaneous respiration. Thus, using tidal volumes greater than the dead space to ventilate the alveolar space. The basis of its physiology stems from the Bernoulli concept first described in 1738, demonstrating that the velocity of a fluid is greatest when the pressure is least. It refers to the changes in increased flow together with a drop in pressure and energy at the point of a restriction (8). This allows the entrainment of oxygen into the catheter.

High-frequency jet ventilation (HFJV) uses tidal volumes smaller than the dead space. Therefore, there is a reliance on several other physiological mechanisms (9) of gas transport other than bulk flow. Laminar flow (10) facilitates the movement of gases between the lungs and the outside during HFJV due to the differences in the speed of gas moving on the inside versus the outside of a tube. As such,

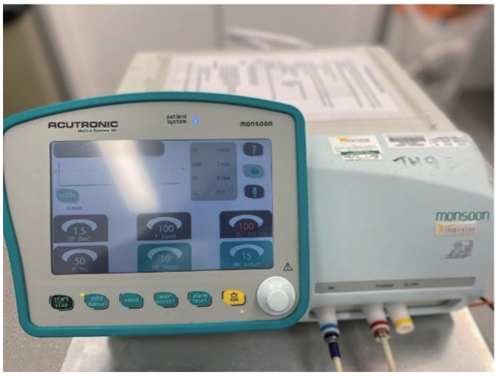

Figure 1 Monsoon jet ventilator (Acutronic Medical Systems AG, 8816 Hirzel, Switzerland).

Figure 2 Twinstream jet ventilator (Carl Reiner GmbH, Vienna, Austria) (12).

bidirectional flow is facilitated. In the centre of the airway, there is a fast-moving channel of air entering the lungs, whilst at the peripheries the gas moves out of the lung thus facilitating oxygenation and hypocarbia.

Taylor type dispersion also plays a part (10). This is the diffusion of high-velocity gases from the centre to the margins of the alveolus facilitating oxygenation by moving it to the alveolar membrane and removing carbon dioxide from the alveolus back into the connecting airways. Pendelluft or collateral ventilation (10) is the movement of gases between the lungs due to changes in compliance and resistance. Therefore, some areas of the lung fill more rapidly or empty quicker than others. This can enable gas flow from one alveolus to another in separate lung units locally recirculating the oxygen rich gas. Molecular diffusion contributes to HFJV all be it minimally. This is the movement of molecules from an area of high to low concentration thus facilitating oxygen entry to low oxygen concentration in the alveolus from the high concentration of oxygen in entrained air. Cardiogenic mixing occurs due to agitation of the lung units by the cardiac ventricular walls. In classical HFJV, expiration was a passive process assisted by the elastic recoil of the lungs and chest wall. In modern ventilators, they account for expiration thus minimising carbon dioxide accumulation thus increasing the potential surgical time.

Types of jet ventilation

HFJV

HFJV is a form of time-cycled pressure-limited ventilation (1). The underlying principle of HFJV is the artificial application of intermittent pulses of high-pressure gas using supra-physiological frequencies (11). High-frequency ventilation also covers the techniques of high-frequency positive pressure ventilation (HFPPV), now obsolete, and high-frequency oscillation ventilation (HFOV) used in neonatal and paediatric medicine.

HFJV allows the intermittent application of a high-pressure gas through a small-bore needle or cannula which may be placed supraglottic, subglottic or transtracheal. It commonly uses frequencies of 110–140/min and uses a fresh stream of gas allowing entrainment of a second gas during its use. Parameters adjustable during HFJV include the rate/frequency of breaths per minute (*f*), the DP, inspiratory time (I time) and the fractional inspired oxygen content (FiO_2).

The 'Monsoon' (Acutronic Medical Systems AG, 8816 Hirzel, Switzerland) (*Figure 1*) and 'Twinstream' (*Figure 2*) (Carl Reiner GmbH, Vienna, Austria) ventilators are currently the two leading the market ranging from 4–600/min. The monsoon delivers heated, humidified jets of air that are interrupted by an electrical solenoid valve adjusting the respiratory rate and creating a square pressure waveform.

The Twinstream ventilator has the added advantage of being able to provide high- and LFJV simultaneously or alternatively, resulting in a bi-level mode of ventilation. It is currently the only device on the market, which uses a microprocessor to allow for this multifunction, and therefore can control the positive end-expiratory pressure (PEEP) and plateau pressure.

LFJV

LFJV delivers high-pressure gases via a narrow cannula commonly using a hand-held device at frequencies of

Figure 3 Sanders jet ventilator (14).

Figure 4 Hunsaker Mon-Jet catheter (Medtronic Xomed, Jacksonville, USA) (17).

10–20 breaths/min for short procedures e.g., laryngoscopy. Oxygenation can be achieved either via a needle, suspension laryngoscope or bronchoscope. Entrainment of air occurs during this process, and it remains of high importance to maintain an open airway to allow for passive expiration, especially at the level of the larynx to avoid any complications by baro- or volutrauma. Similarly, to HFJV, this technique allows for a motionless operating field but is more commonly used during shorter procedures. The adequacy of ventilation can't be assessed via capnography so meticulous observation of clinical signs of a patent airway and consideration of hypercapnia is important in these cases (13).

The currently available manually driven low-frequency jet ventilators include the Sanders (VBM Medizintechnik GmbH-Germany, Sulz a. N. Germany), the ManuJet III (VBM Medizintechnik GmbH-Germany, Sulz a. N. Germany) and the Ventrain (Ventinova Medical B.V., Eindhoven, the Netherlands). The Sanders jet ventilator (*Figure 3*) is a manually operated pressure regulating valve connected to a high-pressure oxygen source. It is squeezed to deliver the jet at the selected pressure, 0.5–3 Bar, and usually held for one second before being released for 4–5 seconds to facilitate passive exhalation.

The Ventrain handheld ventilation device was developed based on the concept of allowing active positive inspiratory pressure whilst also performing active expiration using suction and the Bernoulli effect. This gives it the greatest advantage in comparison to the other manual jet ventilation systems available as it allows for safe expiration reducing the risk of barotrauma. It was initially designed to be used via the transtracheal route using a narrow bore cannula such as Cricath and to be part of the CICO algorithms (15). Duggan *et al.* showed that the use of transtracheal jet ventilation had improved success rates if used during elective cases, but high complication rates (51%) in addition to device failure and barotrauma were reported in CICV cases (15). However, limited experience meant that whilst its use remains available in some hospitals, not many British anaesthetists have experience with it (16).

Jet ventilation delivery systems

Supraglottic delivery systems

All supraglottic delivery systems avoid the use of an ETT facilitating surgical access. Supraglottic jet ventilation may be provided using a fine bore needle attached to the surgical suspension laryngoscope or by using a narrow bore catheter. Whilst this allows for a tubeless surgical field it may come at the expense of movement at the vocal cords and the inability to monitor capnography.

Subglottic delivery systems

Subglottic jet ventilation can be achieved by using the Hunsaker Mon-Jet Catheter (Medtronic Xomed, Jacksonville, USA) or LaserJet Catheter (Acutronic Medical Systems AG, Hirzel, Switzerland). The Hunsaker Mon-Jet Catheter (*Figure 4*) is made from a non-flammable, laser-safe fluoroplastic material with a basket-shaped distal part allowing for central alignment within the airway (18). The largest review to date examining the use of the Hunsaker Mon-Jet Catheter reviewed 837 cases of its use and showed a complication rate of 5.8% (19). This review highlighted the importance of correct patient selection before application and knowledge of the use of jet ventilation and

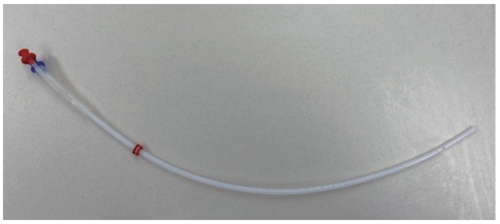

Figure 5 The LaserJet catheter (Acutronic Medical Systems AG, Hirzel, Switzerland).

troubleshooting. Similarly, the LaserJet Catheter (*Figure 5*) is made from non-flammable polytetrafluoroethylene and is now more widely used for laryngeal laser surgery (20). Both catheters allow for side-stream capnography monitoring via a second proximal port.

Transtracheal delivery systems

The transtracheal route may be used as a strategy for oxygenation in cases with difficult airway or surgical access. In those patients with pharyngeal and laryngeal pathology caused by malignancy, surgery or radiotherapy managing the airway is particularly challenging. Tracheal intubation is often impractical and historically a primary tracheostomy has been the chosen technique (21). However, this is not without risk. Transtracheal catheters have the advantage of a minimally invasive technique, with a clear surgical field that can be initiated before the induction of general anaesthesia and maintained after emergence (22). The Ravussins cannula (VBM Medizintechnik GmbH-Germany, Sulz a. N. Germany) is a commonly used transtracheal cannula for microlaryngoscopies. However, complications from barotrauma have occurred because of airway outflow obstruction during jet ventilation (23). The use of automated HFJV has been shown to reduce the risk of complications if operated by an experienced anaesthetist in these transtracheal delivery systems (24).

Role of jet ventilation in difficult intubation

In the 2004 DAS guidelines for the management of the unanticipated difficult intubation (6), jet ventilation was considered an appropriate management in the ‘can’t intubate, can’t ventilate’ scenario. It was later taken out of 2015 DAS guidance (7) in favour of the simplified scalpel-bougie-tube technique to streamline and simplify guidance in these high-pressure scenarios. The evidence suggests that in technically demanding, stressful CICO scenarios with notoriously challenging human factors jet ventilation is associated with a high risk of device failure and barotrauma (15). Resultantly the authors recommend following the DAS guidance of scalpel-bougie-tube in the first instance in a CICO scenario.

Discussion

Complications arising from the use of jet ventilation include barotrauma, catheter malposition and inadequate gas exchange (*Table 2*). Equipment failures and technical complications may occur due to catheter blockage, kinking, malpositioning or dislodgment/disconnection during use. For this reason, an allocated staff member should be continuously visualising and ensuring a good jet catheter position, usually done by a second anaesthetist or trained nurse. Poor gas exchange during jet ventilation commonly leads to hypercapnia and/or hypoxia. Subglottic jet catheters such as the LaserJet catheter now have a sidestream capnography port and the Monsoon ventilator provides warmed humidified gas jets.

Barotrauma and air entrapment have been reported in case studies (25,26), but remain a rare complication (5,18). A 10-year review of jet ventilation complications showed that the use of subglottic jet ventilation catheters was the single independent factor leading to barotrauma (23).

Several studies have tried to determine predictive factors for complications and adverse events in these cases. A review showed an association between obesity and previous airway surgery and the occurrence of adverse events (27). Similarly, Tang *et al.* showed that a BMI greater than 25 was linked to hypercapnia in patients undergoing HFJV (28).

Complications and adverse events can be avoided by regular training and meticulous attention and care during use, ensuring safe settings are used and alarms are engaged. There are no set standards or guidelines for the use of jet ventilation, but most departments rely on their own standard operating procedure and experienced staff. The volume of gas delivered is set by three main parameters including the DP, the frequency (f) and inspiratory time (IT), normally set as a percentage. *Table 3* gives suggestions for commonly used settings.

To ensure safe use and avoid the occurrence of barotrauma, alarms should be set for the pause pressure and peak inspiratory pressure. The pause pressure is measured at the distal jet ventilation catheter and reflects the mean airway pressure. Once the alarm is engaged any further inspiration is stopped. The fractional-inspired oxygen (FiO_2) can also

Table 3 Suggested range for jet ventilation settings

Parameter	High-frequency jet ventilation	Low-frequency jet ventilation
Frequency (f)	100–140	4–12
Driving pressure (bar)	0.2–3	0.2–1.8
Inspiratory time (%)	0.3–0.4	0.3–0.4
Pause pressure, mbar	5–10	5–10
Peak inspiratory pressure, mbar	15	15

Figure 6 The Evone ventilator (Ventinova Medical B.V., Eindhoven, The Netherlands).

be altered and is commonly reduced to 0.4 during laser surgery. Several automated devices now contain a laser setting which automatically reduces the FiO_2 and signals a message when it is safe to use the laser.

Hypercapnia can be overcome by increasing the DP and thus tidal volume and by decreasing the frequency or inspiratory time to increase the exhalatory time. An increase in the frequency without a change of the other parameters may inadvertently lead to hypercapnia. Hypoxia can be managed by increasing the DP, and inspiratory time of FiO_2. Supplemental oxygen can be provided via high-flow nasal cannulas (e.g., Optiflow).

Awareness of human factors and communication are paramount for patient safety, especially during shared airway surgery. As highlighted in previous major reviews such as the Fourth National Audit Project in the United Kingdom and Closed Loop Analysis in the United States, failures in communication can lead to complications in airway management (5,29). A single-centre study introduced a jet-ventilation communication protocol including a surgical-led debrief, and staff and equipment checklists and showed that manual jet ventilation can be performed safely even with inexperienced staff (30). This study emphasised the importance of a detailed theatre team discussion before the start of the list, discussing the type of jet ventilation used and the rescue plans available. The recently published human factors guideline for anaesthesia also encourages the use of focused team debriefs encouraging all theatre team members to participate and plan through possible challenges and complications of the planned procedure (31). Consequently, clear team communication and pre-procedural planning are required when using jet ventilation to ensure optimal patient outcomes.

Further applications of vet ventilation

In recent years, the use of jet ventilation in head and neck surgery and intensive care has expanded to other specialities including hepatobiliary surgery, cardiac interventions, thoracic surgery, and extracorporeal lithotripsy for urological procedures. The use of HFJV was described in percutaneous radiofrequency ablation of liver tumours due to its ability to reduce ventilation-related liver movement. Thermal ablation is used as a curative therapy for liver tumours and precise use of the ablation device is key. A case report by Biro *et al.* reports the use of a subglottic HFJV via a disconnected ETT using a DP of 1.8 bar and a frequency of 150 cycles/min. Spiral computed tomography (CT) images were taken before and post-HFJV and showed a clear reduction in the cranio-caudal swinging of the liver from 20 to 5 mm (32).

A case series using a 3D marker shield and CT imaging to analyse the ventilation-associated movement for patients undergoing stereotactic liver ablation under general anaesthesia showed similar results. In the mentioned case, the jet catheter was placed through an ETT which was left open to air to allow the escape of gases (33). However, an ETT adapter such as the 'LifePort' by Bunnell allows for easy switching between conventional and jet ventilation, as its triple port system allows for jet injection and pressure monitoring. Similarly, the Evone ventilator (Ventinova Medical B.V., Eindhoven, The Netherlands) in *Figure 6* allows for multifunction ventilation, allowing not only ventilation via an ETT or Trilumen tube by controlling inspiration and expiration flow from a set PEEP to a set peak pressure and *vice versa* (34) but also HFJV when an open airway is present.

Similarly, HFJV has been used as a method of ventilation for patients undergoing cardiac ablation for atrial fibrillation and other arrhythmias. A retrospective study comparing its use to standard ventilation showed reduced procedural times and a higher success rate secondary to less atrial motion (35). Whilst the number of randomised controlled trials comparing its use to standard ventilation in cardiac intervention remains limited, there is evidence of improved outcomes. Moreover, the use of HFJV is expanding further, recently being used in a case report of a patient undergoing a Mitraclip insertion for valve repair (36).

Extracorporeal shockwave lithotripsy is another procedure in which the use of HFJV has been investigated to reduce kidney movement intra-operatively and case series and studies have shown improved surgical conditions and reduced operative times (37,38). Whilst additional uses of HFJV to minimise movement from ventilation are expanding across other specialties further studies are required to precisely evaluate its advantages and risk profile.

Conclusions

Jet ventilation is a commonly used technique to ventilate patients during maxillofacial and laryngotracheal surgery. Alongside apnoeic nasal oxygenation, THRIVE and percutaneous tracheostomies, jet ventilation provides another effective technique in the arsenal of the maxillofacial and laryngotracheal anaesthetist. Here we have shown modern advancements have made jet ventilation safe, operational, and an appropriate technique for patients and clinicians alike. Future recommendations include national standardised operating procedures and the continued investment and multidisciplinary participation in jet ventilation training for all anaesthetists for both the difficult and elective airway.

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Footnote

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References

1. Evans E, Biro P, Bedforth N. Jet ventilation. Continuing Education in Anaesthesia Critical Care & Pain 2007;7:2-5.
2. Klain M, Smith RB. High frequency percutaneous transtracheal jet ventilation. Crit Care Med 1977;5:280-7.
3. Babinski M, Smith RB, Klain M. High-frequency jet ventilation for laryngoscopy. Anesthesiology 1980;52:178-80.
4. Singh P, Mishra P, Tiwari T, et al. Airway Consideration in Maxillofacial Trauma. The Traumaxilla 2022;4:19-25.
5. Cook TM, Woodall N, Frerk C, et al. Major complications of airway management in the UK: results of the Fourth National Audit Project of the Royal College of Anaesthetists and the Difficult Airway Society. Part 1:

anaesthesia. Br J Anaesth 2011;106:617-31.
6. Henderson JJ, Popat MT, Latto IP, et al. Difficult Airway Society guidelines for management of the unanticipated difficult intubation. Anaesthesia 2004;59:675-94.
7. Frerk C, Mitchell VS, McNarry AF, et al. Difficult Airway Society 2015 guidelines for management of unanticipated difficult intubation in adults. Br J Anaesth 2015;115:827-48.
8. Lin T, Smith T, Pinnock C. Fundamentals of Anaesthesia. vol. One. Fourth. Cambridge University Press; 2017.
9. Slutsky AS, Drazen JM. Ventilation with small tidal volumes. N Engl J Med 2002;347:630-1.
10. Chang HK. Mechanisms of gas transport during ventilation by high-frequency oscillation. J Appl Physiol Respir Environ Exerc Physiol 1984;56:553-63.
11. Ihra G, Gockner G, Kashanipour A, et al. High-frequency jet ventilation in European and North American institutions: developments and clinical practice. Eur J Anaesthesiol 2000;17:418-30.
12. TwinStream ONE. Available online: https://www.carlreiner.eu/products/twinstream-one/
13. Baer GA, Paloheimo M, Rahnasto J, et al. End-tidal oxygen concentration and pulse oximetry for monitoring oxygenation during intratracheal jet ventilation. J Clin Monit 1995;11:373-80.
14. VBM MANUJET III. Available online: https://murraysurgical.ie/wp-content/uploads/2019/10/VBM-Manujet-III.pdf
15. Duggan LV, Ballantyne Scott B, Law JW, et al. Transtracheal jet ventilation in the ‘can’t intubate can’t oxygenate’ emergency: a systematic review. Br J Anaesth 2016;117:i28-38.
16. Heuveling DA, Mahieu HF, Jongsma-van Netten HG, et al. Transtracheal Use of the CriCath Cannula in Combination With the Ventrain Device for Prevention of Hypoxic Arrest due to Severe Upper Airway Obstruction: A Case Report. A A Pract 2018;11:344-7.
17. Adyanthaya SS, Truscott J, Hutchings P. A novel technique for the insertion of a Hunsaker Mon-Jet catheter. Anaesthesia 2014;69:1177-8.
18. Davies JM, Hillel AD, Maronian NC, et al. The Hunsaker Mon-Jet tube with jet ventilation is effective for microlaryngeal surgery. Can J Anaesth. 2009;56(4):284-90.
19. Hu A, Weissbrod PA, Maronian NC, et al. Hunsaker Mon-Jet tube ventilation: a 15-year experience. Laryngoscope 2012;122:2234-9.
20. Galmén K, Harbut P, Freedman J, et al. The use of high-frequency ventilation during general anaesthesia: an update. F1000Res 2017;6:756.
21. American Society of Anesthesiologists Task Force on Management of the Difficult Airway. Practice guidelines for management of the difficult airway: an updated report by the American Society of Anesthesiologists Task Force on Management of the Difficult Airway. Anesthesiology 2003;98:1269-77. Correction appears in Anesthesiology 2004;101:565.
22. Bourgain JL, Desruennes E, Fischler M, et al. Transtracheal high frequency jet ventilation for endoscopic airway surgery: a multicentre study. Br J Anaesth 2001;87:870-5.
23. Jaquet Y, Monnier P, Van Melle G, et al. Complications of different ventilation strategies in endoscopic laryngeal surgery: a 10-year review. Anesthesiology 2006;104:52-9.
24. Ross-Anderson DJ, Ferguson C, Patel A. Transtracheal jet ventilation in 50 patients with severe airway compromise and stridor. Br J Anaesth 2011;106:140-4.
25. Craft TM, Chambers PH, Ward ME, et al. Two cases of barotrauma associated with transtracheal jet ventilation. Br J Anaesth 1990;64:524-7.
26. Nunn C, Uffman J, Bhananker SM. Bilateral tension pneumothoraces following jet ventilation via an airway exchange catheter. J Anesth 2007;21:76-9.
27. Helmstaedter V, Tellkamp R, Majdani O, et al. High-frequency jet ventilation for endolaryngotracheal surgery--chart review and procedure analysis from the surgeon's and the anaesthesiologist's point of view. Clin Otolaryngol 2015;40:341-8.
28. Tang F, Li S, Chen L, et al. The comparison of various ventilation modes and the association of risk factors with CO2 retention during suspension laryngoscopy. Laryngoscope 2011;121:503-8.
29. Joffe AM, Aziz MF, Posner KL, et al. Management of Difficult Tracheal Intubation. Anesthesiology 2019;131:818-29.
30. Matrka L, Soldatova L, deSilva BW, et al. Airway Surgery Communication Protocol: A Quality Initiative for Safe Performance of Jet Ventilation. Laryngoscope 2020;130 Suppl 1:S1-S13.
31. Kelly FE, Frerk C, Bailey CR, et al. Implementing human factors in anaesthesia: guidance for clinicians, departments and hospitals: Guidelines from the Difficult Airway Society and the Association of Anaesthetists: Guidelines from the Difficult Airway Society and the Association of Anaesthetists. Anaesthesia 2023;78:458-78.
32. Biro P, Spahn DR, Pfammatter T. High-frequency jet ventilation for minimizing breathing-related liver motion

during percutaneous radiofrequency ablation of multiple hepatic tumours. Br J Anaesth 2009;102:650-3.
33. Galmén K, Freedman J, Toporek G, et al. Clinical application of high frequency jet ventilation in stereotactic liver ablations - a methodological study. F1000Res 2018;7:773.
34. Vetinova Medical. Evone: Controlled inspiration and expiration. Available online: https://VentinovamedicalCom/Evone/ 2023.
35. Goode JS Jr, Taylor RL, Buffington CW, et al. High-frequency jet ventilation: utility in posterior left atrial catheter ablation. Heart Rhythm 2006;3:13-9.
36. Gangwani MK, Haroon F, Priyanka F, et al. Optimizing a MitraClip procedure with high frequency jet ventilation. Baylor University Medical Center Proceedings 2023;36:101-2.
37. Cormack JR, Hui R, Olive D, et al. Comparison of two ventilation techniques during general anesthesia for extracorporeal shock wave lithotripsy: high-frequency jet ventilation versus spontaneous ventilation with a laryngeal mask airway. Urology 2007;70:7-10.
38. Gadzhiev N, Oibolatov U, Kolotilov L, et al. Reducing kidney motion: optimizing anesthesia and combining respiratory support for retrograde intrarenal surgery: a pilot study. BMC Urol 2019;19:61.

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