# Air entrainment during high-frequency jet ventilation in a model of upper tracheal stenosis

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**Background:** Previous work has demonstrated that when high-frequency jet ventilation (HFJV) is applied above an airway stenosis, higher distal airway pressures are produced compared with when the same ventilation is delivered below the stenosis (BSV). This study aimed to investigate the mechanisms underlying this finding.

**Methods:** HFJV was applied to a model of laryngo-tracheal stenosis with the jet located above the stenosis (ASV), with a catheter passed through the stenosis (TSV) or with HFJV delivered by a side port BSV. For each configuration and over a range of diameters of stenosis (2.5–8.5 mm), distal tracheal pressures and delivered minute volume were measured and air entrainment estimated. Experiments were repeated using the same model with the addition of a simulated ‘pharynx’ around the stenosis.

**Results:** Distal airway pressures, minute volumes, and air entrainment were consistently higher during ASV compared with BSV and TSV. The presence of the ‘pharynx’ made no significant difference to airway pressures or air entrainment. Delivered minute volumes varied between ASV, TSV, and BSV, and were also dependent on the stenosis diameter. With ASV, there appeared to be a range of stenosis diameters (4.0–5.5 mm) which ‘maximized’ minute volumes.

**Conclusions:** The results suggest that the high airway pressures generated during ASV are the consequence of air entrainment and this effect, although reduced slightly, is maintained in the presence of the model pharynx. In contrast to the previous work, no significant entrainment occurred during BSV. If applicable to patients, these data suggest that ASV HFJV should be avoided in small diameter stenoses, but provides more efficient gas delivery and greater distending pressures with larger stenoses. BSV HFJV produces lower distal pressures and more consistent oxygen concentrations of injected gas across a range of stenosis diameters.

**Keywords:** airway, calibre; airway, obstruction; model, jet ventilation; ventilation, high frequency jet; ventilation, respiratory impedance

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‡These data were presented in part to the American Association of Anesthesiologists Meeting, Las Vegas, October 2004 and 3rd Biannual Meeting of the European Society for Jet Ventilation, Vienna, November 2004.

# Letter:

**High frequency jet ventilation above, passed through and below the airway stenosis.**

Gerlinde Mausser
British Journal of Anaesthesia, 3 Dec 2007 [Full text]

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We read with great interest the article by Buczkowoski et al. entitled “Air entrainment during high-frequency jet ventilation in a model of upper tracheal stenosis.” The authors concluded that ventilation delivered below the stenosis (BSV) is the safest option from the point of view of low tracheal pressure and consistent oxygen concentrations of injected gas. We have several concerns about the suggestions made by the authors. From our experience, the results of in vitro studies cannot always be transfered to the patients. Transtracheal jet ventilation is an invasive technique and in obese patients, small infants and neonates the transcutaneous puncture of the cricothyroid membrane may be difficult. Although the airway pressure might be lower in this technique, displacement of the cannula, cervical emphysema, pneumomediastinum and pneumothorax are frequently described in literature 1, 2, 3. Subglottic jet ventilation via transglottal canulas is associated with the movement of the cannula; air trapping and barotrauma can occur if the air outflow is not ensured. Further clinical investigations should underscore the results of the presented study. Contrary to the author’s results and conclusion we prefer in our department supraglottic superimposed high/low frequency jet ventilation (SHJFV) via jet laryngoscopes during endolaryngotracheal surgery, because it is a non-invasive ventilation technique 4, 5. In our over ten years of experience with this technique, as well as in literature studies, no barotrauma has been detected in supraglottic superimposed high/low frequency jet ventilation (SHJFV) 6. The jet laryngoscope is a modification of a Kleinsasser laryngoscope with two integrated nozzles applying simultaneously high and low frequency jet ventilation. The nozzles are integrated in the wall of the jet laryngoscope, therefore optimal jet propulsion is ensured and the distance between nozzle orifice and the stenosis remains constant 7. The results of the method may be based on a precise body weight depending basic setting of the high and low driving pressure of the jet ventilator, which possibly influence air entrainment and airway pressure. When using high frequency jet ventilation in endolaryngotracheal surgery the method with the lowest invasiveness for the patient should be choosen whenever possible.

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## Reply to Drs Mausser and Schwarz

12 December 2007

Piotr W. Buczkowski ,
J. P. Thompson

## Send letter to journal:

Re: Reply to Drs Mausser and Schwarz

Dear Sir,

We would like to thank Drs Mausser and Schwarz for their interest in our article.(1) We would agree that as with all laboratory investigations, extrapolation of findings to clinical practice must to be carefully guarded and is certainly not appropriate to small infants, neonates or obese patients. However, our aim was to add to knowledge of the basic physical processes involved during HFJV and not to promote a preferred way of administration of HFJV. The particular advantage of our model is its simplicity which allows us to study different configurations under controllable and reproducible steady state conditions. We recognise the limitations of the model and problems of direct extrapolation of the results, but would note that high pressures or hyperventilation have been previously reported in animal and human studies using HFJV. These points are clearly stated in the discussion.

Our main conclusion was that air entrainment is likely to be responsible for the higher airway pressures observed during ASV and a lack of entrainment during BSV results in lower airway pressures. The degree of stenosis also has a significant effect on entrainment, delivered volumes and pressures distal to the stenosis. We would congratulate Drs Mausser and Schwarz on their clinical series using SHFJV but feel it is impossible to directly compare SHFJV with HFJV: SHFJV steady state is difficult if not impossible to define, the jet is placed laterally in relation to the airway inlet, and the distance from the jet orifice to the airway inlet is longer. Furthermore, the jet laryngoscope used during SHFJV described by Rezaie-Majd et al(2) encroaches on the supralaryngeal area; air entrainment (or obstruction to outflow of gases) cannot be assumed to be similar ASV using a cannula. Although these authors stated that no barotrauma has been detected in supraglottic SHFJV we note that recordings of airway pressure were presented for only 13 patients (out of 1515) and would suggest that it is impossible to draw any conclusions regarding airway pressures on such low numbers. In addition, the results of that paper and our own are not directly comparable because of differences in ventilator settings, degree of stenoses (which are not stated) and other clinical variables. In contrast to Rezaie-Majd's assumptions that:

'The pressure below the stenosis cannot be higher than the pressure above the stenosis with any supraglottic technology. Stenosis will reduce the inflow of jet gas, and the resulting distal airway pressure behind the stenosis will be reduced as well'(2),

our data show that the converse is true using ASV. We agree that further work is required before our results could be safely applied to clinical practice. However when choosing a method of ventilation in cases of upper airway stenosis we would strongly recommend caution and attention to the details of configuration of the interface between the ventilator and respiratory spaces of the patient's lung.

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