HIGH FREQUENCY JET VENTILATION V. MANUAL JET VENTILATION DURING BRONCHOSCOPY IN PATIENTS WITH TRACHEO-BRONCHIAL STENOSIS

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SUMMARY
Six patients with airway stenosis were submitted to bronchoscopy under general anaesthesia. Each was ventilated with a gas mixture of 50% oxygen and nitrogen using successively manual jet insufflation (JV) using the Sanders technique at 20 b.p.m., and high frequency jet ventilation (HFJV) at rates of 150, 300 and 500 b.p.m. The effects on alveolar ventilation were assessed by blood-gas analysis and the transcutaneous monitoring of carbon dioxide tension. It is concluded that HFJV achieves satisfactory operating conditions, and provides adequate gas exchanges up to a rate of 300 b.p.m. At the faster rate some degree of hypoxaemia and hypercarbia were noted. The correlation between PaCO₂ and transcutaneous carbon dioxide tension was satisfactory.

During bronchoscopy ventilation must achieve immobility of the bronchial tree and its patency while insuring adequate alveolar ventilation. For that purpose Sanders (1967) introduced the manual gas injector. More recently, Eriksson and Sjöstrand (1977) have demonstrated the efficiency of a low volume–high frequency ventilation (60 b.p.m.). The purpose of this study is to compare the effects of much higher frequency ventilation (Carion et al., 1982) on gas exchange, with those of manual jet ventilation, in patients with airway stenosis.

PATIENTS AND METHODS
Six patients were submitted to bronchoscopy before laser surgery (Toty et al., 1981). Three had tracheal stenosis, and three stenosis of a main bronchus.

After standard premedication and the induction of anaesthesia with thiopentone, neuromuscular blockade was achieved with a continuous infusion of suxamethonium. A Storz bronchoscope was used. This had been modified to provide jet ventilation by the addition of a brass tube (2.5 mm i.d.) welded on the side and opening within the lumen 5 cm above the tip (Vourc'h et al., 1980). The tube was connected either to a Sanders injector or to the jet ventilator (MK 800 Acutronic Systems AG (Switzerland)). In both cases a mixture of 50% oxygen and nitrogen was inflated under a pressure of 500 kPa. Manual jet ventilation at 20 b.p.m. and high frequency jet ventilation at 150, 300 and 500 b.p.m. were applied during 10-min periods. Inspiratory time was kept constant at 20% of each cycle during high frequency ventilation.

Samples were collected from a radial artery for the measurement of blood-gas tensions. Samples were taken before induction with the patients breathing room air, and at the end of each period of ventilation. Carbon dioxide tension was measured continuously using a transcutaneous electrode (Kontron medical) heated to 42 °C, placed on the thorax below the clavicle.

Results are expressed as mean ± standard deviation; statistical analysis used analysis of variance and linear regression analysis. Statistically significant differences were assumed at P<0.05.

RESULTS
Baseline values of PaO₂ and PaCO₂, with the patients breathing room air, were 10.2 ± 0.87 and 4.3 ± 0.68 kPa, respectively. Manual jet ventilation provided good oxygenation (PaO₂ 23.2 ± 4.8 kPa) and moderate to marked hypoxaemia (PaCO₂ 3.09 ± 0.88 kPa; range 2.13–4.26 kPa). Arterial blood-gas tensions were similar when high frequency jet ventilation was used at 150 b.p.m. (PaO₂ 23.8 ± 5.7 kPa; PaCO₂ 3.3 ± 1.0 kPa). At 300 b.p.m. PaO₂ remained stable (21.6 ± 5.7 kPa), whereas PaCO₂ increased slightly to 4.28 ± 1.37 kPa. At 500 b.p.m. PaO₂ decreased to 16.7 ± 7.9 kPa and PaCO₂ increased further (5.39 ± 1.84 kPa; range 3.46–8.25 kPa).
Individual results are presented in figures 1 and 2. There were no statistically significant differences between the blood-gas tensions at the different frequencies of ventilation.

A close correlation was found between the transcutaneous carbon dioxide tension and the arterial $P_{CO_2}$, both measured at the end of each period of ventilation (fig. 3).

DISCUSSION

Although several methods of ventilation have been used for bronchoscopy and laryngoscopy under general anaesthesia, manual jet ventilation (Sanders, 1967) and high frequency jet ventilation (Eriksson and Sjöstrand, 1977; Babinski, Smith and Klain, 1980) are used widely in current clinical practice.

Manual jet ventilation can be achieved through a rigid bronchoscope (Cromwell, Hirshman and McCullough, 1975; Vourc'h et al. 1980), a fibroscopic bronchoscope (Satyanarayana et al., 1980) or a laryngoscope (Oulton and Donald, 1971). This method provides variable results, partly as a result...
of the manual injection and of the dilution of ventilating gases by air (Jardine, Harrisson and Healy, 1975); Satyanarayana reported moderate to severe hypocarbia, and Winerman and colleagues (1982) several instances of hypercarbia.

Eriksson and Sjöstrand (1974, 1977) introduced high frequency jet ventilation with good results, which were not entirely confirmed by Babinski, Smith and Klain (1980). However, the differences can probably be accounted for by the use of different apparatus, Eriksson and Sjöstrand using a pneumatic valve which avoided air entrainment. In all these previous studies frequencies of 60 b.p.m. or 100 b.p.m. were used.

This report describes the application of manual jet ventilation and high frequency jet ventilation in patients with severe tracheal or main bronchus stenosis. The main problem during high frequency—low volume ventilation using jet or oscillations is carbon dioxide elimination (Smith, Klain and Babinski, 1980; Rossing et al., 1981; Slutsky et al., 1981). Smith, Klain and Babinski (1980) reported that, in dogs ventilated with a fluidic jet ventilator at \( F_{IO_2} = 1.0 \), \( PaO_2 \) remained stable (59.9–64.5 kPa) at frequencies between 100 and 600 b.p.m. and \( PaCO_2 \) remained less than 5.32 kPa up to rates of 400 b.p.m. However, \( PaCO_2 \) increased to 7.45 kPa at 600 b.p.m. Our results demonstrate that arterial gas tensions are identical during either manual jet ventilation (20 b.p.m.) or high frequency jet ventilation at 150 b.p.m. At 300 b.p.m. \( PaO_2 \) was unchanged; one of the six patients was hypercapnic. At 500 b.p.m. \( PaO_2 \) decreased in all patients and \( PaCO_2 \) increased in all but one. The comparison of jet ventilation and high frequency jet ventilation shows no statistical difference, on account of the wide range of values—a factor which increased with the increase in the rate of ventilation.

The problem of carbon dioxide elimination and the variability in the results make continuous monitoring of \( PaCO_2 \) mandatory and this can be provided by a transcutaneous electrode (Eberhard, Mindt and Schäfer, 1981). This is particularly important as there are no chest movements to guide the anaesthetist. Furthermore, a brief bronchoscopic procedure under general anaesthesia does not induce haemodynamic instability which may interfere with the transcutaneous evaluation of arterial \( PCO_2 \) (Eletr et al., 1977).

From the endoscopist's point of view, high frequency jet ventilation is preferable to manual jet ventilation because the tracheo–bronchial wall remains perfectly immobile.

In conclusion, high frequency jet ventilation can be used for short bronchoscopic procedures with \( F_{IO_2} \) 0.5 at a rate of 150 or 300 b.p.m., even in patients with severe airway stenosis. Alterations in \( PaCO_2 \) can be detected by a transcutaneous \( PCO_2 \) electrode.

REFERENCES


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**COMPARAISON ENTRE JET-VENTILATION A HAUTE FREQUENCE ET JET-VENTILATION MANUELLE AU COURS DE LA RESECTION AU LASER DE STENOSES TRACHEO-BRONCHIQUES**

**RESUME**

Six patients porteurs d’une sténose des voies aériennes ont subi une bronchoscopie sous anesthésie générale. Tous étaient ventilés par un mélange oxygène 50%/protoxyde d‘azote 50% en utilisant successivement une jet-ventilation manuelle (JVM) selon la technique de Sanders à 20 i.p.m., et une jet-ventilation à haute fréquence (JVHF) à des fréquences de 150, 300 et 500 i.p.m. Les effets sur la ventilation alvéolaire étaient objectivés par l’analyse des gaz du sang et la surveillance transcutanée de la P CO2. Il en a été déduit que la JVHF permet d’obtenir des conditions opératoires satisfaisantes et une hémorragie correcte jusqu’à la fréquence de 300 i.p.m. A des fréquences plus élevées, apparaissent une hypoxémie et une hypercapnie. La corrélation entre la P CO2 transcutanée et la P CO2 a été trouvée satisfaisante.