Technical Report

Evaluation of the jet injector in paediatric fiberoptic bronchoscopes

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The use of the Sanders venturi system during bronchoscopy in adults has been studied extensively. Its use in paediatric bronchoscopy has been limited because small changes in the characteristics of the system may produce large changes in the patient. With jet ventilation, peak inflation pressures and flow rates are influenced by the driving pressure, diameter and shape of the bronchoscope, the diameter of the injector and its length and angle from the axial line of the bronchoscope. Storz 3 mm, 4 mm and 5 mm rigid fiberoptic bronchoscopes were evaluated in a test lung with an injector of 1.5 mm internal diameter fixed in the side-arm at 20 degrees to the axial line. Pilling 3 mm, 4 mm and 5 mm rigid fiberoptic bronchoscopes were also examined using the standard injector with a 0.89 mm orifice in the axial line. The Storz bronchoscopes produced consistently higher peak inflation pressures and flow rates at all driving pressures in spite of the relatively large angle of the injector from the axial line. Caution is advised in the use of the Storz injector system as excessively high inflation pressures may be reached.

Key words

SURGERY: bronchoscopy; ANAESTHETIC
TECHNIQUES: jet ventilation.

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Anaesthesia for bronchoscopy in children can be carried out successfully using a combination of topical analgesia, light general anaesthesia, and spontaneous ventilation.¹ At times, however, mechanical ventilation is desirable. The Sanders venturi system has been used in such cases in both adults and children.²⁻⁴

When jet ventilation is used in bronchoscopy, peak inflation pressures and peak flow rates are influenced by the driving pressure, the inside diameter of the injector, the diameter of the bronchoscope, and the leak around the bronchoscope.^{2,5,6} In a study of the Sanders injector with paediatric bronchoscopes we demonstrated that the distance of the injector from the proximal end of the bronchoscope and the angle of the jet from the axial line are also important in small-diameter bronchoscopes.⁴

At the Hospital for Sick Children, Toronto, we now have Storz fiberoptic bronchoscopes in which both the angle of the injector and its distance from the proximal end are predetermined. An injector with an internal diameter of 1.5 mm enters the bronchoscope through a side-arm at an angle of 20 degrees to the axial line and is locked in position.

To determine the combined effects of the jet angle and the size of the injector on peak flow rates and inflation pressures, we evaluated bronchoscopes in a test lung.

Method

The test lung consisted of a 5 L plastic bottle with a sealed top fitted with a pressure gauge and a length of corrugated tubing to act as a trachea. The bronchoscope was sealed into this test trachea. The

FIGURE 1 Inflation pressures obtained with Storz and Pilling bronchoscopes at various driving pressures.

compliance of this apparatus was 0.1 L/kPa (0.01 L/cm H₂O).

A pneumotachograph (Hewlett Packard Digital Pneumotach 47303 A) was placed between the corrugated tube and the test lung to measure peak flow rates of driving gas plus entrained air. Plateau inflation pressures in the lung model were measured with a water manometer. Repeat measurements of both flow and pressure showed little variation. Results quoted represent the means of three measurements at each level of driving pressure.

The injector was connected to the bulk compressed air source. A regulator permitting variable driving pressures and a toggle switch allowing intermittent flow were interposed between the injector and the approximately 410 kPa (60 psi) gas source.

Measurements were made using Storz fiberoptic bronchoscopes of 3 mm, 4 mm, and 5 mm diameter (models 10338 B, C, and E). Our 4 mm instrument is not equipped with the snap-on connector for the injector, but has a similar side-arm with a port of appropriate size through which the injector can be inserted and then fixed in position. Measurements were also made in Hollinger 3 mm, 4 mm, and 5 mm fiberoptic bronchoscopes (Pilling 52-2575, 52-2578, and 52-2580) with a Sanders injector of 0.89 mm diameter in the axial line.

Results

The Storz bronchoscopes produced higher peak flow rates than did the Pilling bronchoscopes at all driving pressures in the same test lung. Inflation

pressures obtained with the Storz instruments were also consistently higher.

The highest inflation pressures were obtained in the 3 mm Storz bronchoscope where the plateau pressure exceeded 7.4 kPa (75 cm H₂O) at a driving pressure of approximately 210 kPa (30 psi). In the 3 mm Pilling bronchoscope a driving pressure of about 280 kPa or 40 psi produced an inflation pressure of 3.1 kPa (32 cm H₂O).

Discussion

The use of the Sanders injector technique in bronchoscopy provides an alternative to spontaneous or manual ventilation during these procedures when the airway must be shared with the surgeon. However, our results show that this technique can be hazardous with unfamiliar equipment. In adults, the danger of excessive pressures is minimized by the discrepancy between the size of the trachea and the size of the bronchoscope that exists in most patients. In the paediatric population, there is less likely to be a significant leak around the bronchoscope and thus higher inflation pressures may result.

Although dangerously high inflation pressures were seen only in the 3 mm and 4 mm Storz bronchoscopes, it must be remembered that the use of an aspirator or other instrument in the larger bronchoscopes partially obstructs the lumen and will further increase the higher inflation pressure.

The alignment of the injector with respect to the axial line of the bronchoscope is also a factor in determining entrainment of air and, therefore, flow to the patient. Miyasaka *et al.* demonstrated that a deviation of the jet from the axial line by as little as six degrees caused a 50 per cent reduction in the inflation pressure obtained in their 3.0 mm test bronchoscope.⁴ Since the Storz bronchoscopes and injectors produced higher inflation pressures in spite of the relatively large angle of the injector from the axial line, it is evident that the large bore of the jet more than compensates for this increased angle. Users of this system should be aware of the potential hazards and adjust driving pressures accordingly.

An injector of smaller diameter would be expected to lessen the risk of inappropriately high plateau pressures. At the present time we do not have such an injector available to us.

The introduction of new injector equipment for

FIGURE 2 Peak flow rates obtained in Storz and Pilling paediatric bronchoscopes at various driving pressures.

paediatric bronchoscopy demands careful evaluation prior to clinical use as small alterations in the angle or diameter of the jet will greatly affect the performance of the system.

The use of the Sanders venturi system during bronchoscopy in adults has been studied extensively, but its use in paediatric bronchoscopy has been limited as small changes in the characteristics of the system may produce large changes in the patient.

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Résumé

L'utilisation de l'injecteur de Sanders pour les bronchoscopies de l'adulte a été largement étudiée. Son emploi en bronchoscopie pédiatrique a été plutôt restreint parce que des menus changements dans les caractéristiques du système peuvent avoir des conséquences importantes pour le patient. Dans la ventilation à jet, les pressions et les débits de crête sont fonction de la pression à la source, du diamètre et de la forme du bronchoscope, du diamètre et de la longueur de l'injecteur et de l'angle que celui-ci forme avec l'axe du bronchoscope. Sur un poumon expérimental, nous avons évalué un montage composé de bronchoscopes rigides à fibre optique de marque Storz de 3, 4, et 5 mm munis d'un injecteur à diamètre interne de 1.5 mm fixé à l'orifice latéral formant un angle de 20° avec l'axe du bronchoscope. Nous avons aussi étudié la performance des bronchoscopes Pilling 3, 4 et 5 mm munis cette fois d'un injecteur standard à diamètre interne de 0.89 mm placé dans l'axe du bronchoscope. Les bronchoscopes Storz ont produit des pressions et des débits de crête plus élevés à tous les niveaux de tête de pression en dépit de l'angle relativement ouvert que forme l'injecteur avec l'axe du bronchoscope. On recommande donc d'être attentif à cette caractéristique du bronchoscope Storz qui permet d'atteindre des pressions excessives dans les voies aériennes.