TWO CASES OF BAROTRAUMA ASSOCIATED WITH TRANSTRACHEAL JET VENTILATION

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SUMMARY

Two patients suffered barotrauma whilst undergoing transtracheal jet ventilation (TTJV). In the first, TTJV was provided by a Sanders injector and in the second it was given by a high frequency jet ventilator. Barotrauma was a consequence of the expiratory pathway becoming blocked. The mechanism of barotrauma and a method of airway pressure monitoring during TTJV are discussed. It is recommended that meticulous care is taken to ensure an adequate path for expiration when jet ventilation is used.

KEY WORDS

Complications; barotrauma. Ventilation: jet, high frequency.

Anaesthesia for head and neck surgery presents special problems. Maintenance of a clear airway, adequate ventilation and good surgical access are of prime importance. Techniques of insufflation or jet ventilation have been described in an attempt to achieve these aims. Two cases of barotrauma are presented; both occurred in patients in whom transtracheal jet ventilation (TTJV) was used.

CASE REPORTS

Patient 1

A female child with Treacher Collins syndrome (mandibulofacial dysostosis) and weighing 9.8 kg presented at the age of 18 months for craniofacial surgery involving reconstruction of the lateral orbital floor and malar area. She exhibited all characteristics of the Treacher Collins syndrome, with downward sloping palpebral fissures towards the outer canthi, sunken cheek bones and a hypoplastic mandible. Previous anaesthesia for palatal surgery had presented difficulties both with maintaining the airway and with intubation. It was decided, therefore, to ventilate her lungs using TTJV before securing the airway with a tracheal tube.

The patient was premedicated with oral trimethazine 3 mg kg⁻¹ and atropine 0.02 mg kg⁻¹ i.m., supplemented in the anaesthetic room with i.v. midazolam. Lignocaine with adrenaline was infiltrated into the pretracheal skin below the level of the cricoid cartilage. A 14-gauge VBM cricothyroid cannula (VBM Medizintechnik, W. Germany) was inserted into the trachea and connected to a Sanders oxygen injector. This type of cannula is manufactured from Teflon and is kink resistant. It has a Luer Lok connection for jet ventilation in addition to a 15-mm connection for use in an emergency with a respiratory bag or conventional ventilator. Its use has been advocated for paediatric ventilation for laser surgery and endoscopic procedures and in small children with laryngeal obstruction [1].

TTJV was performed using 50% oxygen in nitrous oxide.

This patient presented a grade IV difficult intubation according to the classification proposed by Cormack and Lehane [2]. Unsuccessful attempts to see the vocal cords were made with a variety of laryngoscopes, the larynx being viewed finally via an endview fibreoptic endoscope. This was inserted through the cords with 4.5-mm Portex tracheal tube fitting snugly over it. When visual confirmation of entry into the trachea was made, the Portex tube was passed through the...
larynx. TTJV continued without problem throughout this procedure until the tracheal tube was inserted through the larynx. Immediately following this manoeuvre, subcutaneous emphysema appeared at the root of the neck. Jet ventilation was stopped and the endoscope removed. Thereafter, the patient's lungs were ventilated with intermittent positive pressure via the oral tracheal tube. Clinical examination revealed signs of bilateral pneumothoraces, and two chest drains were inserted. The planned surgery was postponed and tracheotomy performed. The patient was transferred to the paediatric intensive care unit where the pneumothoraces resolved over the ensuing 4 days, with no evidence of persistent air leak.

Patient 2

A 60-yr-old man weighing 76 kg presented for laser surgery to a laryngeal tumour. He had noticed a change in his voice over several months, but did not complain of breathing difficulties. Clinical examination revealed a mild inspiratory stridor, poor dentition and an anticipated grade III difficult intubation [2]. Fibreoptic laryngoscopy under local anaesthesia had shown a supraglottic tumour obscuring 67% of the laryngeal inlet. Tomographic views of the neck revealed that the trachea was narrowed and deviated to the right. Palliative laser vaporization of the bulk of the tumour was planned in order to improve the patency of the airway.

Because of expected difficulty with intubation and requirements for good surgical access, transtracheal high frequency jet ventilation was chosen as the method of ventilation, with early recourse to tracheotomy if required.

Temazepam 30 mg was given orally as premedication. In the operating theatre an i.v. infusion was inserted i.v. and monitoring with pulse oximetry, ECG and non-invasive arterial pressure commenced. Oxygen was administered by mask and anaesthesia induced slowly with an i.v. infusion of propofol. A good airway was maintained easily and a cricothyroid puncture performed with a 12-gauge Wallace cannula. Neuromuscular block was produced with suxamethonium 100 mg i.v. Transtracheal high frequency jet ventilation (HFJV) was provided by the Penlon Bromsgrove Jet Ventilator set to deliver 120 b.p.m. at a driving pressure of 20 lbf in$^{-2}$ (138 kPa). Ventilation was monitored by observation of chest expansion and expiratory gas flow through the mouth. Anaesthesia was maintained with an infusion of propofol and bolus doses of alfentanil and atracurium.

Laser surgery proceeded without difficulty for 1 h. At that time, however, tumour debris and bleeding became excessive and subcutaneous emphysema appeared at the root of the neck. The procedure was abandoned therefore, and a gum elastic bougie passed into the larynx. Transtracheal ventilation was stopped temporarily whilst a tracheal tube was passed, with difficulty, over the bougie. As the bougie was removed, a large escape of gas was heard at the proximal end of the tube. Manual ventilation of the lungs with 100% oxygen was commenced and tracheotomy performed. The patient's peripheral perfusion was poor and the pulse oximeter failed to register. Arterial pressure and ECG were unchanged. Auscultation suggested a right pneumothorax and a chest drain was inserted. A chest x-ray showed a left pneumothorax which was drained also and the patient's condition improved rapidly. Further radiographs demonstrated mediastinal emphysema, extensive subcutaneous emphysema and pneumoperitoneum. The neuromuscular block was antagonized and the patient allowed to wake up, following which he was transferred to the intensive therapy unit (ITU). The chest drains were clamped 24 h after admission to the ITU and removed within 48 h of insertion. Serial chest x-rays confirmed rapid resolution of both the pneumothoraces and emphysema, thus supporting the absence of a persistent air leak.

DISCUSSION

Various methods of jet ventilation or insufflation and air entertainment have been reported. Transtracheal jet ventilation was described in 1971 [3]. It has been advocated in situations where immediate tracheal intubation may not be possible [4] and in anaesthesia for direct laryngoscopy [5]. Tobias, Nassar and Richards reported a method of nasotracheal jet ventilation for microlaryngeal procedures using a Sanders injector [6]. The following year, Pybus, O'Connor and Henville devised a catheter technique using the control module of the Nuffield Anaesthetic Ventilator [7]. High frequency percutaneous transtracheal jet ventilation using a small catheter has also been studied [8]. The results showed adequate gas exchange at rates of ventilation up to 200 b.p.m. at tidal volumes approaching deadspace volume.
It has been advocated for use in both children [1] and adults [9] undergoing laser surgery of the larynx. Advantages of jet ventilation include a clear operative field for the surgeon [10], good respiratory gas exchange [11], elimination of the risk of ignition of a tracheal tube by laser [12] and decreased risk of broncho-aspiration of blood and debris [13].

Both of our patients suffered barotrauma following obstruction to expiration. Vivori [14] reported the death of a 4-yr-old child after excessive intrapulmonary pressure resulted in a massive right pneumothorax and cardiovascular collapse during use of a method of nasotracheal ventilation similar to that described by Pybus, O’Connor and Henville [7]. Rupture of the human lung is known to result also in interstitial emphysema and perivascular spread to the mediastinum [15].

The mechanism of barotrauma is open to speculation. It is probable that, in both patients, obstruction of the expiratory pathway during TTJV caused a sudden large increase in airway pressure and thus alveolar pressure, resulting in alveolar rupture, pulmonary interstitial emphysema, pneumomediastinum and pneumothorax. Indeed, in the second patient the pressure generated must have been so great as to force gas from the mediastinum into the peritoneal space. It is clear from both case reports that the initiation of barotrauma was a sudden, instantaneous event, as the patients did not suffer persistent pleural air leak.

Measurement of airway pressure is difficult using methods of jet ventilation and air entrainment. No attempts were made to measure airway pressure in these patients. Instead, as is common practice, reliance was placed upon close observation and a high index of suspicion to detect expiratory outflow obstruction. In patient No. 2 it is possible that the series of events may have been prevented by the monitoring of airway pressure.

The Penlon Bromsgrove Ventilator incorporates an airway monitoring system which can display baseline, mean or peak airway pressures. The mean airway pressure monitor has an upper alarm limit (overpressure) adjustable between 10 and 70 cm H₂O which, if activated, interrupts the driving gas. This facility has been utilized when performing HFJV via two insufflation catheters passed perorally into the trachea during laryngeal surgery. One catheter is used to deliver jet ventilation and the other to monitor airway pressure. A modification of this concept in patient No. 2 by insertion of a second transtracheal cannula would have allowed increasing airway pressure to be detected and HFJV to be stopped automatically. A 22-gauge cannula would suffice for pressure monitoring purposes but, if venting of gas is required, a cannula of much larger diameter would be needed.

In patient No. 1, obstruction to expiration occurred when the fibreoptic endoscope and tracheal tube was inserted through the larynx. The patient has since undergone uneventful reconstructive surgery using an identical method of anaesthesia, with the exception that transtracheal jet ventilation was discontinued before instrumentation of the larynx. This ensured that no ventilation occurred whilst expiration was obstructed. In patient No. 2, expiratory obstruction occurred when blood and tumour debris suddenly became excessive.

This report emphasizes the need to ensure unobstructed expiration during transtracheal jet ventilation. It highlights the speed with which expiratory outflow obstruction can lead to severe and possible fatal barotrauma. We therefore advocate the use of a second percutaneous tracheal cannula for airway pressure monitoring during transtracheal HFJV.

REFERENCES
9. Scheck PA, Mallios C, Knecht P, van der Schans EJ. High


