Case Report

Percutaneous transtracheal jet ventilation as a guide to tracheal intubation in severe upper airway obstruction from supraglottic oedema

K. Chandradeva*, C. Palin, S. M. Ghosh and S. C. Pinches

Magill Department of Anaesthesia, Queen Mary’s Hospital, Sidcup DA14 6LT, UK
*Corresponding author. E-mail: chandra.chandradeva@qms.nhs.uk

We report two cases of severe upper airway obstruction caused by supraglottic oedema secondary to adult epiglottitis and Ludwig’s angina. In the former case, attempts to intubate with a direct laryngoscope failed but were successful once percutaneous transtracheal jet ventilation (PTJV) had been instituted. In the case with Ludwig’s angina, PTJV was employed as a pre-emptive measure and the subsequent tracheal intubation with a direct laryngoscope was performed with unexpected ease. In both cases recognition of the glottic aperture was made feasible with PTJV by virtue of the fact that the high intra-tracheal pressure from PTJV appeared to lift up and open the glottis. The escape of gas under high pressure caused the oedematous edges of the glottis to flutter, which facilitated the identification of the glottic aperture. We believe that the PTJV should be considered in the emergency management of severe upper airway obstruction when this involves supraglottic oedema.

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Maintenance of a clear and secure airway is fundamental to every general anaesthetic technique. Unfortunately reports of airway catastrophies leading to mortality still appear in the literature.1–3 The introduction of percutaneous transtracheal jet ventilation (PTJV) has made a significant contribution in maintaining oxygenation and ventilation in patients with a difficult airway.4 We describe two cases of severe upper airway obstruction where direct laryngoscopic tracheal intubation was performed with ease by using PTJV.

Case 1

A male bus driver of 54 yr of age, weight 73 kg, height 1.7 m, was apparently well when he returned home from work but felt a slight sore throat on retiring to bed. He woke up during the early hours complaining of a severe sore throat, coughing, vomiting, choking, and fever. His condition deteriorated and approximately 10 h later he was brought to the accident and emergency (A&E) department. On arrival he had stridor, was dyspnoeic, confused, restless, and was unable to phonate appropriately. His past medical history included irritable bowel syndrome and peptic ulcer disease and he was allergic to penicillin. He smoked 30 cigarettes a day. He had a ventiliatory frequency of 28 b.p.m., pulse 129 beats min⁻¹, arterial pressure 162/88 mm Hg, temperature 38°C, and $\text{SpO}_2$ 98% on breathing oxygen via a variable performance mask. Approximately 20 min after arrival and whilst being assessed by the clinical staff, he had a grand mal fit and was given an i.v. injection of diazepam 10 mg. He became semiconscious and developed a compromised airway. At this stage, the on-call anaesthetist was asked to attend. The Glasgow Coma Score was 6 (out of 15) and his airway appeared to be partly obstructed, but with some difficulty it was feasible to perform facemask ventilation. Although spontaneous breathing was present it was judged to be inadequate. The results of arterial blood gas analysis were as follows: pH 6.84, $P_{a\text{CO}_2}$ 42.5 kPa, $P_{a\text{O}_2}$ 15.2 kPa, $S_{\text{aO}_2}$ 100%, HCO₃⁻ 19 mmol litre⁻¹, BE −21 mmol litre⁻¹. After administration of propofol 75 mg and suxamethonium 100 mg, tracheal intubation was attempted by a staff grade anaesthetist and subsequently by two consultant anaesthetists but failed. The glottic area was very oedematous and it was not possible to identify the anatomy of the glottic area, which was obstructed by a large mass thought to be arising from the epiglottis. A cannula
(VBM Jet Ventilation Catheter™, 14 gauge) cricothyroidotomy was performed and it was connected via Manujet III (VBM)™ to a wall outlet that delivers oxygen at 4 bar (58 psi). A driving pressure of 3 bar (44 psi) was selected and, after confirming that the cannula was intra-tracheal by aspirating air, PTJV was commenced. The escape of gas via the oral cavity was confirmed and a direct laryngoscopy was attempted again. A 8.0-mm cuffed oral tracheal tube was passed using a tracheal tube introducer with ease by the consultant anaesthetist who had previously failed to intubate the patient. The intubation was found to be feasible because the glottic area appeared to be lifted up and opened, and the escape of gas under high pressure caused the edges of the glottic aperture to flutter.

A CT scan of the head, a lumbar puncture, and microbiological analysis of the cerebrospinal fluid were normal. His white blood cell count (WCC) was 25.1 · 10⁹ litre⁻¹ with a neutrophil count of 22.2 · 10⁹ litre⁻¹. A diagnosis of adult epiglottitis was made on the basis of history, presentation, appearance at nasendoscopy, and biopsy results. The nasendoscopy showed oedematous epiglottis with several areas of leukoplakia. The biopsy specimen taken from the left-sided superior edge of the epiglottis showed extensive ulceration and necrosis with associated acute inflammation in the subepithelial stroma. No malignancy was seen. The patient was treated with aciclovir, ceftriaxone, clindamycin, and metronidazole. The sputum sample failed to grow any organism. Extubation was carried out on the seventh day in the operating theatre following a check nasendoscopy. Having made a good recovery he was discharged home 13 days after admission to the hospital. He did not require a tracheostomy.

### Case 2

A housewife of 54 yr of age, weight 95 kg, height 1.5 m, was brought to the A&E department complaining of a swollen, painful throat and difficulty in breathing 2 days after extraction of two lower teeth by a dentist. There was no history of any other medical conditions. Pre-existing medications were zopiclone and amitriptyline taken for sleep. She smoked 20 cigarettes a day. One day after dental treatment the patient began to experience an increasingly painful throat and dysphagia, and was unable to sleep lying flat as a result of increasing difficulty in breathing. The following day the symptoms progressed causing an increased amount of throat swelling and pain, marked shortness of breath, stridor, and fever. Her WCC was 24.0 · 10⁹ litre⁻¹ with a neutrophil count of 21.4 · 10⁹ litre⁻¹. A diagnosis of Ludwig’s angina was made and the anaesthetists were asked to assess the airway. On examination the patient was found to be dyspnoic, sitting upright on a trolley, able to phonate only in monosyllables, and unable to swallow although there was no drooling. The submandibular area was grossly swollen, indurated, and erythematous. The patient was alert with a ventilatory frequency of 24 b.p.m, heart rate 110 beats min⁻¹, and SpO₂ 97% on 2 litres of oxygen via nasal cannula.

There was trismus restricting the mouth opening to less than 1 cm. She was administered co-amoxiclav, metronidazole, nebulized epinephrine and salbutamol but these measures had no noticeable affect on the stridor or respiratory distress.

Discussion

In the case of adult epiglottitis two consultants and one staff grade anaesthetist failed to perform intubation using conventional measures such as the Macintosh laryngoscope and tracheal tube introducer, but intubation was feasible once PTJV had been instituted. In Case 2, PTJV was instituted initially and subsequent tracheal intubation was found to be unexpectedly easy. We believe that the intubation was facilitated by virtue of the high intra-tracheal pressure effect on the glottis. The high intra-tracheal pressure from the jet ventilation appeared to lift up and open the collapsed glottis and allowed for better visualization of the glottis. Furthermore, the escape of gas under high pressure caused the oedematous edges of the glottis to flutter, which enabled us to identify the glottic aperture. We intend to name this phenomenon glottic flutter. Our experience of PTJV assisted intubation matches that of Patel.5 In his retrospective study over a period of 4 yr among patients who were admitted to the intensive care unit for ventilation for acute respiratory
failure, 29 could not be intubated and facemask ventilation was found to be ineffective. Of these patients successful PTJV was instituted in 23 patients and subsequent intubation was performed successfully on 20 patients. Patel postulated that the high intra-tracheal pressure from the jet ventilation opened the collapsed glottis making visualization of the glottic aperture better. In this case series there were some non-fatal complications and other authors4,5,7 have also reported similar low complication rates. Potential complications of PTJV include: a kinked cannula, catheter misplacement, haemorrhage at the site insertion, barotrauma, oesophageal injury, surgical emphysema, and gas embolism. In order to minimize complications it is imperative to verify that air can be aspirated from the cannula into a large syringe before the use of high-pressure ventilation. In addition to this, in our practice we doubly confirm the intra-tracheal position of the cannula by demonstrating a capnograph trace. This can be achieved by connecting the cannula to a capnograph monitor as in Case 2. Barotrauma is less likely if an initial inflation pressure of less than 4 bar (58 psi) is used.8 Initial high-pressure ventilation should be performed particularly cautiously. During PTJV it is important to keep the upper airway as open as possible and to verify deflation of the lungs through the upper airway. As standard i.v. cannulae are easily kinked it is recommended to use kink-resistant cannulae.9 Although it is recommended to pass the cannula through the cricothyroid membrane, occasionally we have found in our practice that siting the cannula between the tracheal rings, preferably second and third, is easier. The presence of the cannula in the intertracheal ring space provides the opportunity to proceed with a percutaneous dilatational tracheostomy in a patient with a difficult airway should the intubation fail. There are a few case reports of successful use of this technique in failed intubation11 and ‘cannot intubate, cannot ventilate’ situation.12 Other techniques that could be used to overcome airway obstruction include: emergency tracheostomy,13 surgical (‘stab’) cricothyroidotomy,14 and fibre-optic intubation.15 It has been recommended that the laryngeal mask airway with manual ventilation be considered in the emergency management of severe upper airway obstruction as a result of supraglottic oedema when facemask ventilation had failed.16 Movement of air bubbles with air flow to and from the glottic opening in a spontaneously breathing patient has been used as a guide to perform tracheal intubation.17 However, we could not use this technique in our patients as they had already developed severe airway obstruction and their respiratory effort deemed to be inadequate.

In the early 1950s, Jacoby and co-workers18 used a 14-gauge needle to puncture the trachea of five patients who were extremely difficult to intubate. Oxygen was then insufflated through the needle while the authors proceeded with tracheostomy or intubation. In 1971, Spoerel and colleagues19 demonstrated that blood gas levels could be maintained if patients were ventilated transtracheally with intermittent jets of oxygen (30 litre min⁻¹ at 2 bar) through a 16-gauge needle, despite the induction of respiratory paralysis. Since then several other human studies and case reports have documented the efficacy of PTJV in providing oxygenation and ventilation.4,5,20–23 PTJV is relatively safe, simple and easy to learn and its most important benefit is immediate oxygenation24 by two mechanisms.4 The first, and most important, is by bulk flow of gas through the cannula. The second is by translaryngeal entrainment of room air via the Venturi principle, depending on the degree of airway patency above the jet. Studies in models and in experimental animals have demonstrated that gas flow through a 16-gauge cannula in response to a driving pressure of 4 bar (58 psi) is approximately 500 ml s⁻¹.18 Even in the absence of additional translaryngeal gas entrainment via Venturi effect, this flow rate is clearly adequate to provide excellent ventilation and oxygenation.25–27 This is evidenced by numerous animal studies as well as human studies and case reports documenting normocarbia or hypocarbia and hyperoxia in both elective surgical patients and patients with complete upper airway obstruction managed with PTJV for varying periods of time.6,28–29 In animal studies (normal dogs) in which distal airway pressure was measured during PTJV through a 16-gauge needle, it was demonstrated that low frequency ventilatory rates, for example less than 30 b.p.m., produced peak airway pressures between 20 and 50 cm H2O.18 Expiration is passive secondary to the elastic recoil of the lung and chest wall. The PTJV is described in detail by Benumof30 and Stewart.31

Based on our observations we believe that, in addition to its recognized efficacy in maintaining oxygenation and ventilation, the PTJV has an important role to play in assisting tracheal intubation in very difficult airway situations as a result of supraglottic oedema.

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