General anaesthetic management for laser resection of central airway lesions in 85 procedures

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The perioperative course of 41 patients undergoing 85 endoscopic laser resections of central airway lesions under general anaesthesia was reviewed. The CO₂ laser was used in 60 procedures and the Nd:YAG in 25. Intravenous anaesthesia and Venturi ventilation were utilized for 65 resections; 20 procedures involved predominantly inhalation anaesthesia via the ventilating bronchoscope. Significant intraoperative complications included arterial desaturation (SaO₂ < 90 per cent) in 26 per cent of procedures, and refractory hypertension requiring vasodilator therapy in 19 per cent. Intravenous anaesthesia was associated with a longer duration of recovery room care and a higher incidence of postoperative respiratory complications (delayed extubation, recovery room re-intubation and ventilation, and post-extubation stridor). Inhalation anaesthesia appeared to simplify the intraoperative management and decrease the incidence, duration and severity of immediate postoperative respiratory complications.

Although laser resection of central airway lesions using topical anaesthesia has been described,¹ many feel that surgical requirements and patient safety are best provided under general anaesthesia.^{2,3} The difficulties of balancing the surgical requirements of airway access, immobility, and obtundation of respiratory reflexes against the need for ventilation, oxygenation, haemodynamic stability and narcosis have been reviewed.²⁻⁴

Initially the use of the CO₂ laser restricted the anaesthetist to an intravenous technique and Venturi ventilation. The

advent of the Nd:YAG laser, which is transmissible by fibre-optics, enabled the administration of inhalation anaesthesia via conventional ventilating systems. Controversy exists as to which anaesthetic and ventilation techniques are more suitable.²⁻⁵

This report summarizes our anaesthetic experience with 85 procedures involving both laser types, and outlines the perioperative complications encountered with intravenous and inhalation techniques.

Methods and Results

Data collection

The hospital records of all patients undergoing laser resection of obstructing airway lesions were reviewed by the authors to determine the patients' age, diagnoses, site of obstruction, related medical problems, and the nature of any previous therapy related to the airway pathology.

From the anaesthetic record we determined the type of laser used, the mode of induction, maintenance and the duration of general anaesthesia, and the method of ventilation. Documentation of the following intraoperative problems was noted: SaO₂ < 90 per cent, clinical difficulty with ventilation and/or PaCO₂ > 6 kPa (45 mmHg), hypertension necessitating vasodilator therapy, haemorrhage, and any arrhythmias requiring treatment.

The recovery room record was reviewed to identify delayed extubation (any patient not extubated within 15 minutes of arrival) and the incidence and duration of postoperative ventilation. The presence of postextubation stridor, wheeze, or other respiratory distress requiring specific treatment (heliox, racemic epinephrine, or re-intubation) was noted. The duration of recovery room observation was calculated.

The date and cause of any postoperative death prior to hospital discharge were noted.

Patient population

Between March 1984 and June 1986, 41 patients with symptomatic airway obstruction underwent 85 laser

Key words

EQUIPMENT: laser: CO₂, laser: Nd:YAG; SURGERY: bronchoscopy; VENTILATION: Venturi, positive pressure; ANAESTHESIA: inhalation, intravenous.

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resections (1–10 procedures per patient). The average age was 59 ± 13 years (range: 31–84 years). Carcinoma of the lung accounted for 23 of 31 diagnoses of malignancy. Sixteen patients had had previous thoractomies, including four pneumonectomies. Benign diagnoses in ten patients included four bronchial tumours, one supraglottic stricture, three tracheal strictures, and two bronchial strictures (one following lung transplant). Three patients were ventilator-dependent and five had tracheostomies *in situ*. Four patients had stable coronary artery disease, and two of these patients had sustained a remote myocardial infarction.

All patients were admitted to hospital. Preoperative evaluation included a chest x-ray, ECG, arterial blood gases, and fibre-optic bronchoscopy under local anaesthesia.

Conduct of anaesthesia

Routine preoperative medication was limited to intramuscular glycopyrrolate (0.2–0.4 mg). Less symptomatic patients received sublingual lorazepam in addition. Nebulized salbutamol was given immediately prior to each procedure.

All patients were monitored with an EKG, automatic blood pressure cuff, peripheral nerve stimulator and a pulse oximeter. Previously placed arterial catheters were utilized to monitor blood pressure on three occasions for ventilator-dependent patients.

All anaesthetics were administered by a staff anaesthetist assisted by a resident and/or a specially-trained respiratory therapist. Appropriate precautions against the known laser hazards to patients and operating room personnel were strictly observed.^{6–8,11}

Patients were pre-oxygenated with 100 per cent O_2 . Fentanyl ($1\text{--}2 \mu\text{g}\cdot\text{kg}^{-1}$), diazepam (2.5–5.0 mg) and/or lidocaine ($1\text{--}1.5 \text{ mg}\cdot\text{kg}^{-1}$) were given intravenously. General anaesthesia was induced with thiopentone IV on all but two occasions: one patient with severe stridor was induced with halothane via mask and a second with enflurane via tracheostomy tube. Once controlled manual ventilation was established paralysis was induced with succinylcholine IV and maintained with either a 0.2 per cent succinylcholine infusion or with intermittent non-depolarizing neuromuscular blockers. Patients were categorized according to the technique of maintenance of anaesthesia as either Group I (intravenous only) or Group II (predominantly inhalation).

GROUP I

Maintenance consisted of thiopentone IV, either intermittently or by a 0.4 per cent infusion, supplemented by small doses of fentanyl and/or diazepam. Patients were ventilated through a rigid bronchoscope (Wolf 8.0)

adapted for side-arm Venturi ventilation with either a 50:50 oxygen-nitrogen mixture or with 100 per cent oxygen. Bilateral side vents on the bronchoscope permitted ventilation to the contralateral lung during endobronchial resection.

GROUP II

The anaesthetic machine was modified to deliver volatile agents in a nitrous-oxide free, air-oxygen mixture by splicing an air-oxygen blender (Bird 3M) into the oxygen supply hose between the wall outlet and the anaesthetic machine. The nitrous-oxide – oxygen mixer dial (MDM) was fixed in the “100 per cent oxygen” position and the FiO_2 controlled by the up-stream blender. The FiO_2 was monitored with an oxygen analyser in the inspiratory limb of the circle system. Intermittent positive pressure breathing was achieved via a rigid ventilating bronchoscope with side-arm connection to the semi-closed circle-absorber system. During laser firing, the FiO_2 was lowered to 0.4 to minimize the combustion hazard. Nd:YAG laser beams were transmitted via an optical fibre passed through the suction channel of the flexible fibre-optic bronchoscope (Olympus BF-IT 10) which in turn was introduced through the ventilating bronchoscope (Figure).

In both Groups, patients were left briefly apnoeic during laser firing to minimize airway motion. Airway fumes were aspirated via an endotracheal suction catheter taped to the external surface of the rigid bronchoscope. Intraoperative hypertension refractory to deepening the level of anaesthesia was treated by an infusion of nitroglycerin ($100\text{--}200 \mu\text{g}\cdot\text{ml}^{-1}$). Significant arterial oxygen desaturation (less than 90 per cent) was treated by cessation of laser firing, withdrawal of the rigid broncho-

TABLE I Intraoperative course and complications

	Group I	Group II
Method of anaesthesia	Intravenous	Inhalation
Method of ventilation	Venturi	Conventional
Number of treatments	65	20
Laser type		
CO ₂	56	4
Nd:YAG	9	16
Duration of anaesthesia (hrs)	1.1 ± 0.4	1.2 ± 0.5
Complications (%)		
SaO ₂ < 90%	16 (25%)	6 (30%)
SaO ₂ < 80%	8 (12%)	0 (0)
PaCO ₂ > 6 kPa	2 (3%)	0 (0)
Hypertension*	13 (20%)	3 (15%)
Hypotension*	3 (5%)	1 (5%)
Arrhythmias*	1	1
Awareness	1	0

Duration expressed as mean $\pm$ SD.

*Requiring treatment.

FIGURE Ventilating bronchoscope and attachments for Nd:YAG laser resection.

scope into the trachea if indicated (for CO₂ laser), ventilation with an increased FiO₂ and if necessary, re-intubation with a cuffed endotracheal tube followed by ventilation with 100 per cent oxygen.

Postoperative management

At the end of the procedure, patients were re-intubated with a cuffed endotracheal tube for airway toilet and ventilated with 100 per cent oxygen until recovery of neuromuscular function and protective airway reflexes was satisfactory. Patients were extubated whenever possible in the operating room. Except for the three ventilator-dependent patients who were returned to the ICU, all patients were observed in the recovery room for a minimum of one hour, during which time humidified oxygen was administered and portable chest x-rays obtained.

Complications

Table 1 summarizes the intraoperative complications. There were no intraoperative deaths, pneumothoraces, nor episodes of massive haemorrhage; one minor combustion event involved laser vaporization of the distal tip of the suction catheter, without adverse sequelae.

Significant desaturation complicated about 26 per cent

of procedures. Our impression was that desaturation episodes were more frequent, more severe, and were slower to respond to treatment during periods of Venturi ventilation. Of the six Group II patients who desaturated only two did so during periods of conventional ventilation; a third occurred during a prolonged attempt at intubation and the remaining three desaturated only during brief periods of Venturi ventilation. No Group II patient desaturated to less than 80 per cent, whereas 12 per cent of Group I patients desaturated to levels of 70–79 per cent.

Only two patients, both in Group I, were noted to present clinical difficulty with ventilation. Both episodes were associated with oxygen desaturation, and arterial blood gases in each instance confirmed a PaCO₂ of 10.3 kPa (77 mmHg).

Vasodilator therapy was required for refractory hypertension in about 19 per cent of procedures, regardless of anaesthetic technique. However, our impression was that blood pressure control was simpler using an inhalation technique. Hypotension was an infrequent complication.

Only two significant arrhythmias were documented: one Group I patient developed ventricular bigeminy following tracheal instillation of a 1:500,000 epinephrine solution for haemostasis, and one Group II patient developed frequent ventricular extra-systoles under halo-

TABLE II Recovery room complications

	Group I (Intravenous)	Group II (Inhalation)
Delayed extubation*	36%(22/61)	13%(2/15)
Duration (hrs)	0.25-3.25	0.75-1.5
Prolonged ventilation†	22%(14/63)	5%(1/19)
Duration (hrs)	0.25-2.5	0.75
Postextubation stridor‡	18%(11/61)	7%(1/15)
Re-intubation	10%(6/61)	(0/15)
Pulmonary oedema	1	0
Required naloxone	1	0
Total incidence - one or more complications	51%(32/63)	16%(3/19)
Total time§ in RR (hrs) (range)	2.2 ± 1.2 (1.0-6.0)	1.5 ± 0.5 (1.0-3.0)

*No tube/tracheostomy prep.

†No ventilation prep.

‡Requiring heliox, racemic epinephrine, salbutamol, or re-intubation.

§Time expressed as mean ± SD.

thane anaesthesia. Both responded to IV lidocaine. One Group I patient reported intraoperative awareness.

Table II outlines the postoperative respiratory complications of the 82 patients admitted to the recovery room. Compared to Group II, Group I had a higher incidence of delayed extubation, prolonged ventilation, post-extubation stridor and subsequent re-intubation. The duration of postoperative airway and ventilatory support was generally longer in Group I. One Group I patient required 20 hours of postoperative ICU ventilation after developing pulmonary oedema. The average recovery room stay was greater in Group I than in Group II. The longest stay was in Group I. No patient required re-intubation subsequent to discharge from the recovery room.

Four patients died within seven days of surgery, all following unsuccessful palliation of malignant disease. None of these deaths was felt to be a surgical or an anaesthetic complication. One perioperative myocardial infarction was identified in a Group I patient with known coronary artery disease. His procedure had been complicated by several episodes of arterial desaturation during Venturi ventilation. Two days following surgery, he developed acute congestive heart failure, and ultimately expired of complications after several weeks in the ICU.

Discussion

The increasing utilization of the Nd:YAG laser for the resection of central airway lesions provides the anaesthetist with options in anaesthetic technique. Ours is an uncontrolled retrospective report, not designed to rigorously compare intravenous with inhalation anaesthesia, nor Venturi with conventional ventilation. Increased surgical and anaesthetic experience with time may well

have contributed to the lower complication rates in our Group II patients. Nonetheless, we were impressed with the strong association between intravenous - Venturi anaesthesia and recovery room complications. Our most serious complications - pulmonary oedema, myocardial infarction and postoperative re-intubation - all occurred in our Group I patients.

Nd:YAG resections can be performed through a cuffed endotracheal tube;² however, we have abandoned this technique. The rigid bronchoscope enables better surgical access for control of bleeding, suctioning of blood and secretions, and for piecemeal removal of tumour by forceps.^{3,6,9-11}

The use of Venturi ventilation can facilitate the rapid dispersal of airway fumes, but carries the risk of pneumothorax, excessive airway motion, and distal embolization of blood, secretions and tumour fragments. For Nd:YAG resections we now restrict the use of Venturi ventilation to brief periods following the actual laser firing if required, without having to resort to intravenous maintenance of anaesthesia. Airway motion during laser discharge is eliminated by permitting brief periods of apnoea.

Conventional ventilation during these procedures has been reported to result in a higher mean PaCO₂ compared to Venturi ventilation.²⁻⁵ Most studies report a modest hypercarbia only (PaCO₂ 6.0-8.0 kPa, 45-60 mmHg). We have had no clinical problems using the ventilating bronchoscope, but we did experience ventilation difficulty with two patients using the Venturi system. We do feel, however, that the potential for sudden life-threatening airway obstruction is high regardless of ventilation technique used.

Like Duckett *et al.*,⁴ we encountered a high incidence of intraoperative arterial desaturation. Oxygen saturation in many Venturi-ventilated patients recovered only after re-intubation with an endotracheal tube, whereas conventionally ventilated patients responded quickly to a simple increase in the FiO₂ in almost all instances. The entrainment of room air during Venturi ventilation makes it difficult to achieve a high FiO₂, even when using a 100 per cent oxygen source.

We have found the pulse oximeter to be a reliable and essential monitor for the early detection and correction of hypoxaemia. Arterial blood gas analysis is less useful due to the time delay involved. We do not routinely use indwelling arterial catheters, as many of these patients require multiple procedures over short periods of time.

Endoscopic laser resections predispose to intraoperative arrhythmias due to prolonged airway instrumentation, hypoxaemia, hypercarbia, haemodynamic instability, topical administration of epinephrine-containing solutions, and halothane use. Our low incidence of arrhythmias was probably a consequence of the liberal use

of IV lidocaine, administered for the suppression of reflex coughing and bronchospasm.

A major disadvantage of intravenous anaesthesia lies in the potential for prolonged recovery, particularly following lengthy procedures.³ Although our resection times averaged only about 15 minutes, associated diagnostic, therapeutic and teaching procedures lengthened total anaesthetic time to over one hour. Prolonged somnolence following intravenous anaesthesia was a major contributing factor to our high incidence of postoperative respiratory complications. Like Warner *et al.*,⁵ we have found that inhalation anaesthesia has almost abolished the need for postoperative airway and ventilatory support.

Although none of our patients required re-intubation following discharge from the recovery room, this complication due to reactive airway oedema has been described.⁵ Despite relief of obstruction, deterioration in gas exchange is common following laser surgery² and close monitoring for 24 hours after extensive resections is advisable.

In summary, we conclude that laser resection of central airway lesions is associated with a high incidence of perioperative cardiac and respiratory instability. We propose that inhalation anaesthesia provides for a smoother intraoperative course, and may decrease the incidence and severity of recovery room respiratory complications.

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Résumé

On a révisé le déroulement périopératoire chez 41 patients subissant sous anesthésie générale, des résections de lésions des voies respiratoires, par endoscopie au laser. Le laser CO₂ a été utilisé dans 60 des interventions et le Nd:YAG dans 25. L'anesthésie intraveineuse et la ventilation par Venturi ont été utilisées pour 65 résections; l'anesthésie par inhalation par bronchoscope ventilatoire était prédominante dans 20 interventions. Parmi les complications intraopératoires significatives on retrouvait une désaturation artérielle (SaO₂ < 90 pour cent) dans 26 pour cent des interventions, et une hypertension réfractaire nécessitant une thérapie dans 19 pour cent des interventions. L'anesthésie intraveineuse était associée à un rétablissement plus long en salle de réveil et à une incidence plus élevée dans les complications respiratoires postopératoires (extubation retardée, réintubation et ventilation en salle de réveil, et stridor postextubation). L'anesthésie par inhalation semblait simplifier la conduite intraopératoire et diminuer l'incidence, la durée et la gravité des complications respiratoires en période postopératoire immédiate.