Safety of Interventional Rigid Bronchoscopy Using Intravenous Anesthesia and Spontaneous Assisted Ventilation*

A Prospective Study

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Study Objective: To investigate the safety of total intravenous anesthesia and spontaneous assisted ventilation during interventional rigid bronchoscopy (IRB).

Design: Prospective, noncomparative study.

Setting: A university hospital thoracic endoscopy and laser center.

Patients: Eighty-three patients underwent a total of 124 procedures (including Nd:Yag laser therapy, stent insertions, transbronchial biopsies/bronchoalveolar lavages (TBB/BALs) in transplant patients and others). Results of preanesthesia consultation, endoscopic and anesthesia intervention, perioperative complications, and time spent in recovery room were recorded prospectively.

Results: Respiratory complications occurred in 22 procedures (18 percent) and included severe intraoperative or postoperative oxyhemoglobin desaturations (19 cases), bronchospasms/laryngospasms (two cases), and one recurrent pneumothorax. These complications were mostly related to the endobronchial surgical procedure. Respiratory complications occurred more frequently in patients with American Society of Anesthesiologists (ASA) 3 and 4 status (p<0.005) and in patients with a Karnofsky Performance Scale (KPS) below 70 (p<0.05). No cardiac complications were noted, although 13 patients had significant underlying heart disease. Propofol was used in 121 procedures. Etomidate was used 15 times for induction and three times for both induction and maintenance in patients with ASA status 4 or low blood pressure before induction.

Conclusion: Total intravenous anesthesia and spontaneous assisted ventilation is a well-suited technique for IRB. Severe hypoxemia, however, may occur in approximately 15 percent of patients. This complication is usually related to the procedure itself and is easy to reverse. Propofol is well tolerated in the majority of patients but it must be used with care in patients with poor functional or cardiovascular status.

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ASA = American Society of Anesthesiologists; IRB = interventional rigid bronchoscopy; KPS = Karnofsky performance scale score; TBB = transbronchial biopsy

Interventional rigid bronchoscopy (IRB) includes Nd:YAG laser resection of benign or malignant obstructive airway lesions, stent insertion, large airway dilation, and other procedures performed through the rigid bronchoscope. General anesthesia during intervention must satisfy two requirements. Adequate muscle relaxation may be desirable to perform precise endoscopic resection. Yet respiratory depression should be minimal to avoid anesthesia-related complications.

Several techniques of ventilation and anesthesia have been proposed so the endoscopists and anesthesiologists may share the airway comfortably: conventional mechanical ventilation through the bronchoscope, conventional or manual jet ventilation, and spontaneous assisted ventilation. Inhalation anesthesia with isoflurane is often used with conventional ventilation for maintenance of anesthesia after induction with thiopental sodium or other intravenous hypnotics. Total intravenous anesthesia is used for jet ventilation as well as for spontaneous assisted ventilation. These techniques are efficient but may be cumbersome for certain reasons. Nonflammable gases may cause intolerable operating room pollution through leaks at the bronchoscope or from the patient's nose and mouth. In addition, muscle relaxants are usually used for conventional mechanical ventilation or jet ventilation, but these medications could lead to postoperative respiratory depression. In a recent report, Hanowell et al addressed several questions concerning the rational use of nondepolarizing relaxants for laser resection of endobronchial tumors. The authors found a 10 percent incidence of neuromuscular weakness leading to reintubation in all patients. For the past ten years, IRB at the Thoracic Endoscopy and Laser Center of the CHU Sud has been performed using intravenous anesthetics and sponta-
neous assisted ventilation. The purpose of this study was to prospectively investigate the safety of this technique.

**MATERIALS AND METHODS**

**Patients**

All patients undergoing IRB between November 1990 and March 1991 were eligible for inclusion. Prior to intervention, patients were interviewed and examined by an endoscopist-lung specialist and by an anesthesiologist. Patients completed a written questionnaire on which age, sex, weight, medical history, and medications were noted. Two other questionnaires were completed by physicians. On the first, results of the preoperative electrocardiogram and chest roentgenogram were noted as well as underlying diagnosis, American Society of Anesthesiologists risk classification (ASA), Karnofsky Performance Scale score (KPS), indication for the procedure, and elements pertaining to the intervention: duration, need for laser resection or stent placement, location of airway abnormality, performance of transbronchial biopsy (TBB) or bronchoalveolar lavage (BAL), and anesthetics used. The second questionnaire was a standard anesthesia summary sheet on which details of anesthesia technique and incidents during recovery were noted. At the end of the study, questionnaires and hospital charts were reviewed and duration of hospitalization was recorded.

**Recording of Complications**

Perioperative and immediate postoperative complications were prospectively recorded, including pneumothorax, hemorrhage, hypotension or hypertension requiring treatment, laryngospasm, bronchospasm, arrhythmias, and electrocardiographic evidence suggestive of myocardial infarction. Severe oxyhemoglobin desaturation was defined as at least one reading of SaO₂ below 85 percent or persistent SaO₂ below 90 percent for 30 s or more.

**Anesthesia Technique**

The anesthesia technique usually employed was not altered in any way for this prospective study. No patient received a premedication. After moving patients into the operating suite, a pulse oximeter (Nellcor 200) was placed on the right index finger and an intravenous catheter was inserted in the forearm. Continuous electrocardiographic monitoring was performed and blood pressure was measured every 5 min using an electronic blood pressure cuff. End tidal CO₂ monitoring was not available for this indication because of frequent leaks of gas at the bronchoscope ports. After 3 min of preoxygenation by mask, anesthesia was induced by intravenous administration of propofol (2 to 3 mg/kg), phenoperidine (0.2 to 0.8 mg), and diazepam or midazolam (3 to 8 mg). If patients had unstable or low blood pressure, or were class 4 ASA risk, etomidate (0.2 mg/kg) was used instead of propofol. Five percent lidocaine (40 mg) was sprayed onto the vocal cords during laryngoscopy. After intubation with the rigid bronchoscope, patients were ventilated manually using high-flow oxygen (FiO₂, 0.6 to 1.0) through a bag (Ambu Bag, Ambu, Copenhagen, Denmark) attached via flexible tubing to the ventilation port of the bronchoscope. A security valve prevented pressure in excess of 30 cm H₂O during periods of assisted ventilation. Anesthesia was maintained by repeated injections of 20 to 50 mg of propofol (or 2 mg of etomidate) every 2 to 5 min. Duration between injections was shortened or lengthened as needed, depending on the patient's degree of wakefulness (judged by importance of cough and body movements) and the procedure (profound anesthesia is required for stent insertion). Ventilation was assisted manually via the bag (Ambu) in case of prolonged apnea or oxyhemoglobin desaturation. During laser firing, FiO₂ was decreased below 0.5 to avoid combustion (the only materials in the airway that can burn are the suction catheter and the laser fiber). Patients were extubated when spontaneous ventilation was almost normal and arousal was imminent. Oxygen was administered by nasal cannula and patients were moved to the adjacent recovery room. Oxygen flow was at approximately 5 L/min but could be increased to keep the oxyhemoglobin saturation over 95 percent.

**Rigid Bronchoscopy Technique**

Procedures were performed with a rigid bronchoscope (EFER-Dumon universal bronchoscope). This bronchoscope is a new system that can be assembled with one to three ports and with long and short barrels of different diameters. A set of Silastic caps is provided with or without one or two holes so that all portals can be capped. After intubation, teeth were protected with a gauze pad, and 2 percent lidocaine (50 mg) was administered through a semirigid suction catheter to the trachea and main bronchi. Laser resection was performed through the rigid tube using methods previously described.8 Straight silicone stents were inserted into the large airways (using the EFER stent introducer system.3,12 Inspection of the distal bronchial tree was performed with a fiberoptic bronchoscope (FOB) through the rigid tube before extubation. In lung transplant patients, BAL and fluoroscopically guided TBB were performed using the FOB through a rigid tracheal tube.

**Statistical Analysis**

Data were analyzed using χ² comparison of means; p values less than 0.05 were considered statistically significant.

**RESULTS**

One hundred twenty-four consecutive IRBs were performed under general anesthesia in 83 patients (31 female and 52 male). Indications are listed in Table 1. Procedures included 53 laser resections (43 percent), 26 stent insertions (21 percent), two foreign body extractions (1.6 percent), two Montgomery T-tube placements (1.6 percent), and 33 TBB/BALs in transplant patients (27 percent). In eight patients (6.5 percent), therapeutic resection or stenting could not be performed because of overly extensive airway disease. Mean patient age was 48 years (range, 9 to 85 years). Nineteen patients (22.8 percent) were 65 years or older. Eleven patients (13.2 percent) had undergone double lung transplantation (mean age, 19.1 ± 8.7 years). Thirteen patients (15.6 percent) had significant heart disease (histories of congestive heart failure, angina, previous myocardial infarction, or treated hypertension). Fifty-four procedures (43.5 percent) were performed in patients with ASA class 3 or 4, and 39 (31.4 percent) were performed in patients

Table 1—Indications for 124 Rigid Bronchoscopic Interventions

<table>
<thead>
<tr>
<th>Indications</th>
<th>No. of Procedures</th>
</tr>
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<tbody>
<tr>
<td>Obstructive carcinoma</td>
<td>30</td>
</tr>
<tr>
<td>Lung transplantation</td>
<td>32</td>
</tr>
<tr>
<td>Benign tracheal stenosis</td>
<td>22</td>
</tr>
<tr>
<td>Granuloma resection</td>
<td>11</td>
</tr>
<tr>
<td>Carcinoid tumor</td>
<td>4</td>
</tr>
<tr>
<td>Amyloidosis</td>
<td>5</td>
</tr>
<tr>
<td>Others*</td>
<td>11</td>
</tr>
</tbody>
</table>

*Includes papillomas, hamartomas, schwannomas, foreign bodies, Montgomery T-tubes, and bone marrow transplantation.

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Table 2—Respiratory Complications Occurred in 22 of 124 Interventional Rigid Bronchoscopies (IRB)

<table>
<thead>
<tr>
<th>Complication</th>
<th>Occurrence,*</th>
<th>No. (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peroperative hypoxemia†</td>
<td>15</td>
<td>(12)</td>
</tr>
<tr>
<td>Postoperative hypoxemia</td>
<td>4</td>
<td>(3.2)</td>
</tr>
<tr>
<td>Bronchospasm</td>
<td>1</td>
<td>(0.8)</td>
</tr>
<tr>
<td>Laryngospasm after extubation</td>
<td>1</td>
<td>(0.8)</td>
</tr>
<tr>
<td>Recurrent pneumothorax</td>
<td>1</td>
<td>(0.8)</td>
</tr>
<tr>
<td>Total</td>
<td>22</td>
<td>(18)</td>
</tr>
</tbody>
</table>

*Percent of total number of IRB.
†Including four cases of excessive hemorrhage.

with KPS scores below 70.

Respiratory complications occurred in 22 procedures (18 percent), but they were easily reversible and seldom life-threatening (Table 2). No procedure-related deaths occurred. Complications consisted mostly of severe, perioperative, or postoperative hypoxemia (19 cases) or bronchospasm-laryngospasm (two cases). In four cases, hypoxemia was related to excessive bleeding. Respiratory complications occurred more frequently in patients with ASA 3 and 4 status (p<0.005) and in patients with a KPS below 70 (p<0.05) (Table 3). No cardiac complications (episodes of hypotension or hypertension, severe dysrythmia, or myocardial infarction) were noted, although one patient had transient ventricular ectopy that did not require treatment. Mean duration of procedures was 63 ± 33 min. Propofol was used in 121 procedures (mean dose, 670 ± 320 mg/h). Etomidate was used 15 times for induction and three times for both induction and maintenance (mean dose, 27 ± 20 mg per intervention).

Phenoperidine was used for induction in all but three procedures (mean dose, 0.65 ± 0.22 mg per intervention). Midazolam (mean dose, 3.5 mg ± 2 mg) was used for induction in 46 procedures, and diazepam (mean dose, 5.8 ± 2.6 mg) was used in 64. Mean respiratory rate during spontaneous ventilation was 15 ± 7 and was 13 ± 6 (NS) during assisted ventilation. All patients were extubated in the operating suite. No reintubations were required. Mean recovery room stay was 130 ± 50 min, and mean duration of hospitalization was 2.8 ± 2.6 days.

Table 3—Incidence of Respiratory Complications during the Perioperative Period

<table>
<thead>
<tr>
<th>Age, yr</th>
<th>ASA</th>
<th>KPS</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;65</td>
<td>≥65</td>
<td>1 + 2+</td>
</tr>
<tr>
<td>(17%)</td>
<td>(19%)</td>
<td>(8%)</td>
</tr>
</tbody>
</table>

*p<0.005, patients ASA 3, 4 vs patients ASA 1, 2.
†p<0.05, patients with KPS <70 vs patients with KPS ≥70.

DISCUSSION

Considerable advances have been made in interventional bronchoscopy this past decade. The FOB is being used less frequently alone as operators recognize the advantages of the rigid tube. Improved equipment and technique have led to treatment of increasingly advanced disease. In addition, lung transplantation is offering an exciting new field of intervention for bronchoscopists.

Most experts agree that the number of complications during IRB are inversely proportional to operator experience and technical expertise. Some complications, however, may be anesthesia-related. In our study, many patients had severe underlying medical illnesses (43 percent had ASA 3 or 4 status). There was no evidence to suggest that respiratory complications occurred more frequently in elderly patients. These were significantly more frequent, however, in patients with ASA status 3, 4, and in patients with a KPS below 70. This is not surprising, because these patients had severe underlying disease.

Significant lesions obstructing the large airways make hypoxemia fairly frequent during IRB. The multifactorial etiology of hypoxemia was largely reviewed by McCaughan et al. Hanowell et al described 21 episodes of oxyhemoglobin desaturation among 87 interventions under controlled ventilation and muscle relaxation. Reintubation was required in 10 percent of the procedures and performed in patients with neuromuscular weakness in the postoperative period. In addition, 47 percent of the patients in this study were extubated in the recovery room or in the intensive care unit. No differences were found between the group with postoperative weakness and the group without this complication in age, sex, duration of anesthesia, variety of muscle relaxant, antibiotic administration, and time from last dose of muscle relaxant to reversal. We did not observe this complication in the present study with an anesthesia technique without muscle relaxants. In our study, hypoxemia occurred in 15.2 percent of patients and usually related to the procedure itself: when a bronchus was selectively intubated for needs of resection or when a stent or resected tissue obstructed the rigid tube. In four instances, hypoxemia resulted from excessive hemorrhage. In each case, bleeding was well controlled and treated with the rigid bronchoscope during intervention. Bronchospasm or laryngospasm occurred in only two patients and responded to inhaled bronchodilator and intravenous corticosteroid therapy. Aminophylline was never administered before or after intervention. In high tracheal disease, intravenous corticosteroids were administered routinely during procedures and for 24 h afterwards.

No cardiac complications occurred. This contrasts with earlier reports in which mortality from myocard-
dial ischemia was 0.2 to 0.6 percent. In a recent report, cardiac complications occurred in 27.6 percent and were related to longer duration of general anesthesia and increasing age. With the anesthesia technique used in our study, mild variations of blood pressure occurred, but at no time was hypotension or hypertension noted that required treatment. The absence of cardiac complications in our study may be due to the age and small number of patients. In each of the earlier cited studies, more than 1,000 procedures were studied, and in the study by Hanowell et al of 87 interventions, mean age was greater than in ours (65 years vs 48 years).

Ideal anesthesia for IRB should provide rapid induction, minimal hemodynamic instability, satisfactory ventilation and oxygenation, reduced cough reflex, adequate maxillary and glottic relaxation to permit introduction of the rigid tube, comfortable arousal, and minimal postoperative complications. Light anesthesia allows spontaneous ventilation, although manually assisted ventilation is frequently necessary immediately after intubation, before or immediately after stent insertion, or to reverse oxyhemoglobin desaturation. The need for assisted ventilation is determined by clinical examination (apnea and hypopnea are clinically obvious) and by constant attention to the pulse oximeter. Hypoxemia may be anesthesia-related in cases of hypoventilation and in these circumstances, the anesthesiologist must assist ventilation for a short period or increase FIO2. Leaks through the bronchoscope rarely impede manual ventilation, but in some instances, priority must be given to oxygenation. Closed circuit respiratory assistance is possible by capping all portals on the bronchoscope. Although cough is frequent when light anesthesia is used for airway interventions, individual patient susceptibility and type of procedure performed will determine its importance. In our experience, cough responds well to local administration of lidocaine and rarely impedes operator intervention. A deeper level of anesthesia is required occasionally to avoid excessive “bucking” secondary to nociceptive stimuli produced by movements of the bronchoscope in the tracheobronchial tree.

Propofol (di-isopropylphenol) is a short acting, lipophilic, intravenous hypnotic drug that has been widespread use in Europe for five years. Its pharmacokinetics justify its use for anesthesia in IRB. Propofol has a rapid onset of action (2 to 4 min distribution time), a short half-life (1 to 3 h), and a high body clearance (1,400 to 2,800 ml/min) providing prompt recovery from anesthesia. Patients are usually awake within 15 min after the end of drug infusion. Intermittent bolus injection for maintenance permits anesthesiologists to adapt quality of anesthesia to the needs of the operator and to the sensitivity of individual patients. In our experience, continuous infusion of propofol may be used instead of intermittent injection but frequent boluses are required to maintain an immobile surgical field in patients without muscle relaxants.

It is noteworthy that recognized inconveniences of propofol include a marked tendency for hemodynamic depression resulting in reduction of blood pressure and cardiac output. Precautions for elderly patients therefore include stepwise reduction in infusion rates to decrease the hypotensive response. Administration of a low dose of morphinomimetics and benzodiazepines just prior to induction allows for a decrease of overall propofol dose, thus decreasing potential cardiovascular depression without any side effects on the duration of the recovery period. In patients with ASA 4 status or with known hypotension, etomidate is preferred because of its lesser incidence of hemodynamic depression. Induction doses of etomidate produce transient postoperative suppression of adrenal steroidogenesis. Duration of this side effect seems to be dependent on the etomidate dose and may last for 4 to 48 h after administration. This effect does not preclude the use of etomidate for a single injection or short infusion. In our experience, patients with very poor physical status (ASA 4) had good toleration of IRB with etomidate alone. For the other patients, after an induction dose of etomidate (induction is the most dangerous period in terms of cardiovascular stability), anesthesia was maintained with propofol, which provided greatly improved surgical conditions.

In summary, safe and successful IRB results from team work. Endoscopists comply with demands for ventilation and oxygenation. Anesthesiologists adapt technique in case of hemorrhage, significant airway obstruction, technical difficulties during resection, selective bronchial intubation, or rigid tube changes. Procedure duration is difficult to predict, and depth of anesthesia is often modified during intervention. This requires constant attention on the part of the anesthesiologist. Anesthesia by intravenous hypnotics with short half-lives and spontaneous assisted ventilation appears especially well suited for interventional bronchoscopy. It is safe, simple, and flexible, allowing anesthesiologists to adapt easily to the needs of the operator as well as to those of the patient.

REFERENCES

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Safety of Interventional Rigid Bronchoscopy (Perin et al)

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