Intraoperative Management of the Patient with Severe Lung Disease

Peter D. Slinger, MD, Professor of Anesthesia, University of Toronto Faculty of Medicine, and Staff Anesthesiologist, Toronto General Hospital, Toronto, ON

Overview: general anesthesia should be avoided in patients with severe lung disease whenever possible (regional anesthesia preferred for, eg, repair of fracture of hip or ankle); however, general anesthesia required for some procedures (eg, abdominal surgery)

Case presentation 1: 60-yr-old woman, scheduled for laparotomy for small bowel obstruction, has known emphysema; forced expiratory volume in 1 sec (FEV1) 27% of predicted Preoperative evaluation: recent chest radiograph useful for determining whether bullae present; pressure in bulla equal to mean alveolar pressure (ie, -0.2 to -0.3 cm H2O) and slightly negative compared with surrounding lung tissue; positive pressure ventilation — causes mean alveolar pressure to become positive and bullae to enlarge; positive pressure applied despite use of pressure-controlled ventilation or small tidal volumes; may cause rupture of bullae, possibly resulting in tension pneumothorax that requires insertion of chest drain; therefore, advance planning required (especially when case performed during night or weekend hours); insertion of chest drain may lead to bronchopleural fistula necessitating one-lung ventilation (ie, double-lumen endotracheal tube must be readily available); use of nitrous oxide unsafe in presence of bullae (always causes enlargement)

Arterial blood gases: should be obtained preoperatively to determine whether patient retains CO2, which cannot be predicted clinically (ie, should patient become dependent on mechanical ventilation, baseline CO2 level must be known to properly wean her from ventilator); hypercarbia following administration of supplemental O2 traditionally attributed to removal of hypoxic drive; however, ventilation-perfusion mismatch now known to be primary cause; chronic obstructive pulmonary disease (COPD) — oxygen tension decreased in areas of unhealthy alveoli; this causes pulmonary vasoconstriction, which diverts blood flow from “sick” to healthy alveoli (matching of ventilation to perfusion thus maintained); however, when supplemental O2 administered, more O2 reaches damaged alveoli; hypoxic pulmonary vasoconstriction abolished and blood flow diverted from healthy alveoli; this increases dead space and causes rise in CO2

Case report: tracheobronchial tree of 16-yr-old boy became filled with grain when he fell into silo; endotracheal tube placed upon arrival at emergency department (ED) of community hospital; no obvious chest motion seen; patient remained hypoxicemic and cyanotic but pulses palpable; patient transferred to speaker’s ED after 2 hr of resuscitation; arterial blood gases revealed pH of 6.5, PaCO2 of 500 mm Hg, and PaO2 of 84 mm Hg; patient transferred to operating room (OR) for removal of grain via rigid and flexible bronchoscopy; patient recovered fully (exubtuated by following morning); implications — CO2 can be beneficial; however, at levels >100 mm Hg, CO2 becomes anesthetic; therefore, giving O2 to patient with COPD causes CO2 to rise until individual loses airway

Management of oxygen in patient with COPD: requires titration; O2 saturation of 90% to 92% acceptable; check arterial blood gases; monitor CO2 and postoperative level of consciousness

Anesthesia for patients with COPD: in case patient, speaker performed rapid-sequence induction with administration of propofol, fentanyl, and rocuronium; equal air entry noted on auscultation; after initiation of ventilation, systolic blood pressure (BP) decreased from 120 mm Hg to 50 mm Hg; while pulmonary embolism possible, clinical context suggests dynamic hyperinflation; dynamic hyperinflation — occurs in patients with severe emphysema; caused by inability to exhale, with distal airway collapse; characterized by inability to increase expiratory flows, even with tidal volumes in normal range; manifests as dyspnea on exertion; can cause pulseless electrical activity and cardiopulmonary arrest, with recovery only after resuscitation stopped (Lazarus syndrome)

Treatment of dynamic hyperinflation: reduce tidal volumes; use longer expiratory times; in some patients, addition of positive end-expiratory pressure (PEEP) helpful; PEEP should not be used in patients with chronic bronchitis or asthma; study — in patients with severe COPD being ventilated in intensive care unit (ICU), PEEP added to match intrinsic PEEP; in small minority of patients, hyperinflation occurred when added PEEP reached 60% to 70% of intrinsic PEEP; in very small minority of patients (ie, those with asthma), hyperinflation occurred without any additional PEEP; in patients with emphysema, adding PEEP up to 50% of level of intrinsic PEEP caused deflation, which succeeded in decreasing work of breathing and reducing hyperinflation; measuring PEEP — PEEP believed to serve as pneumatic stent that keeps airways open and enhances deflation; while ventilators used in ICUs able to measure intrinsic PEEP, those used in ORs less accurate; speaker suggests estimating PEEP by...
looking at end-expiratory flow (ie, if end-expiratory flow increases when PEEP added, PEEP deleterious; PEEP beneficial if end-expiratory flow decreases when PEEP added)

Role of thoracic epidural: in case patient, should be considered before induction of general anesthesia; 

Categorizing PH: from anesthesia perspective, PH can be divided into 2 categories (“heart PH” and “lung PH”); heart disease may include systolic dysfunction, diastolic dysfunction, or mitral valve disease; PH more likely related to lung disease in presence of high afterload, right ventricle immediately becomes ischemic; ketamine — poorly regarded; however, recommendations against its use based on studies from 1960s in children with congenital heart disease which showed that, in patients with hypovolemia, pulmonary artery pressures (PAP) increased; when studies repeated in 1980s and 1990s in patients given anesthesia with controlled ventilation, ketamine did not cause increased PAP; dobutamine — considered safe agent; however, recommendations specific for left heart disorders (eg, mitral valve disease); not as effective for right heart disease because it can cause hypotension and tachycardia; vasopressor agents — maintenance of BP priority in treatment; phenylephrine and norepinephrine preferred; in vitro study demonstrating that vasopressin caused no vasoconstriction of human pulmonary arteries has encouraged its use; NO — effective agent but not readily available; prostacyclin (Flolan) displays as effective as NO; may be given through nebulizer

Monitoring: transesophageal echocardiography — recommended for monitoring, however, speaker considers utility limited for determining minute-to-minute changes in patients with severe right heart dysfunction; pulmonary artery catheter — may be useful and particularly informative when pressure rising; however, low PAP not necessarily beneficial because it could indicate right heart dysfunction; continuous measurement of cardiac output in conjunction with PAP more informative (eg, mixed venous saturation)

Suggested Reading


Anesthetic Management of Porphyria

James E. Wolf, MD, Clinical Instructor and Resident, Department of Anesthesiology, University of Vermont College of Medicine, Burlington

Porphyria metabolism: heme synthesis occurs in liver for production of cytochromes and in bone marrow for production of hemoglobin; first and rate-limiting step conversion of succinyl coenzyme A into aminolevulinic acid (ALA) by ALA synthase; aberrations may occur in any enzyme in cascade, and may result in accumulation of intermediates upstream of dysfunctional enzyme; heme serves as negative feedback agent (inhibits synthesis of ALA); stimulation of cytochromes (which occurs with administration of anesthetic drugs) stimulates porphyrin pathway; in patient with porphyria, build-up of upstream substrates results in particular symptom profiles (depending on which substrate accumulates)

Acute porphyria: autosomal dominant disorder with variable expression; patients may be asymptomatic until some event causes heme concentration to decline, resulting in stimulation of ALA synthase, build-up of intermediate substrates, and clinical manifestations; decreased concentration of heme caused by, eg, stress, dehydration, infection, pregnancy; administration of drugs that do not induce cytochrome system preferred; symptoms — abdominal pain (may resemble appendicitis, but without acute abdomen); neuropathy (eg, pain, weakness; neuropathy of phrenic nerve most concerning because of potential for paralysis of diaphragm and respiratory arrest); other manifestations include acute psychosis, seizures, electrolyte
Porphyria crisis: few effective strategies; preoperative administration of midazolam and cimetine safe; ask patients whether they have had recent symptoms, ever had "attack," or recently under stress; information used to stratify risk and decide which drugs useful; Drug Database for Acute Porphyria — helps determine risk; high risk defined as patient currently having symptoms; lowest-risk group includes children (who may be carriers only); intermediate risk includes young men who may have had symptoms in past and women of childbearing age; midazolam probably not porphyrinogenic, even in high-risk patients; database primarily uses case reports and in vivo studies that assess whether drugs stimulate cytochromes; robust prospective data lacking because porphyria is a rare disease.

Intraoperative management: short-acting drugs safer because effects on cytochrome production unlikely to be of sufficient duration to suppress heme; infusions and combined use of many different cytochrome inducers more likely to decrease heme levels; isoflurane not contraindicated, but inhalational agent with shorter elimination time preferred; no contraindications exist for use of opioids or neuromuscular blockers; regional anesthesia — may be used, but neurologic deficits should be documented before placing block; consider whether autonomic nervous system already involved (ie, potential effects of sympathetic block); cardiopulmonary bypass — not associated with increased risk for attacks or worsening of symptoms; pentobarbital — should not be used in patients with porphyria; retrospective data demonstrated that 7 of 10 patients with acute crisis experienced worsening of symptoms following induction with thiopental.

Management of porphyria crisis: supportive care; remove triggering factors; hydration; use sedative and analgesic agents to reduce stress; treat seizures with benzodiazepines or propofol (not barbiturates); treat electrolyte abnormalities and hemodynamic instability; heme analogue may be given to reduce activity of ALA synthase (heme arginate currently favored).

Suggested Reading

Acknowledgments
Dr. Slinger spoke at Maui Anesthesia, presented by Holiday Seminars, and held February 21-28, 2015, in Maui, HI. For information on upcoming CME meetings from Holiday Seminars, please visit holidayseminars.com. Dr. Wolf spoke at the 20th Anniversary Vermont Perspectives in Anesthesia, presented by the University of Vermont College of Medicine, in alliance with the University of Vermont Medical Center, and held March 4-8, 2015, in Stowe, VT. For information on upcoming CME meetings from the University of Vermont College of Medicine, please go to uvm.edu/medicine/cme. The Audio Digest Foundation thanks the speakers and the sponsors for their cooperation in the production of this program.
1. In a patient with emphysema, preoperative chest radiography is recommended to rule out the presence of which of the following?
   (A) Pneumonia  
   (B) Congestive heart failure  
   (C) Bullae  
   (D) Pneumothorax

2. Hypercarbia that results from administration of supplemental oxygen in patients with chronic obstructive pulmonary disease is principally caused by which of the following?
   (A) Loss of hypoxic drive  
   (B) Lack of hypercarbic drive  
   (C) Inability to increase minute ventilation  
   (D) Ventilation-perfusion mismatch

3. A patient with severe emphysema undergoes induction of general anesthesia. Her systolic blood pressure suddenly falls from 120 mm Hg to 50 mm Hg. Auscultation reveals equal air entry. Which of the following is the most likely diagnosis?
   (A) Pulmonary embolus  
   (B) Tension pneumothorax  
   (C) Dynamic hyperinflation  
   (D) Myocardial infarction

4. The mortality rate secondary to respiratory complications is highest after which of the following types of operations?
   (A) Cardiac  
   (B) Thoracic  
   (C) Abdominal  
   (D) Orthopedic

5. With of the following anesthetic agents is contraindicated in patients with pulmonary hypertension (PH)?
   (A) Fentanyl  
   (B) Propofol  
   (C) Ketamine  
   (D) None of the above

6. When treating patients with PH caused by lung disease, which of the following agents is NOT recommended?
   (A) Norepinephrine  
   (B) Phenylephrine  
   (C) Vasopressin  
   (D) Dobutamine

7. Which of the following is(are) most useful for monitoring patients with PH?
   (A) Transesophageal echocardiography  
   (B) Measurement of pulmonary artery pressure  
   (C) Measurement of cardiac output  
   (D) B and C

8. Perioperative planning for patients with acute porphyria should include postoperative mechanical ventilation because of elevated risk for _______ in these individuals.
   (A) Phrenic neuropathy  
   (B) Severe heart disease  
   (C) COPD  
   (D) Multiorgan failure

9. When considering anesthetic agents in patients with porphyria, which of the following is LEAST preferred?
   (A) Midazolam  
   (B) Isoflurane  
   (C) Fentanyl  
   (D) Rocuronium

10. When managing a seizure in a patient with porphyria, which of the following is NOT recommended?
    (A) Benzodiazepine  
    (B) Barbiturate  
    (C) Propofol  
    (D) Phenytoin

Answers to Audio Digest Anesthesiology Volume 57, Issue 43: 1-D, 2-D, 3-C, 4-C, 5-D, 6-A, 7-C, 8-C, 9-C, 10-B

Attention, CME/CE Participants
The cutoff date for logging 2015 credits is December 31, 2015. Test forms received after that date will be accrued to 2016.