Course no:  Course 3
Title:  Respiratory Physiology, Physics & Pathology in Relation to Anaesthesia & Intensive Care
Sub-category:  Peri-operative Management
Topic:  Anaesthesia for Patients with Respiratory Insufficiency
Date:  May 06, 2016
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Country:  Pakistan
Speaker:  Dr. Rashad Siddiqi
I do not have relevant financial interest, arrangement or affiliation that would constitute a conflict of interest
INTRODUCTION

• advances in anaesthetic techniques
  – safe anaesthesia is possible
    – more patients with co-morbids present for surgery who were considered inoperable few years back
  – classical contraindications (e.g., certain lung function parameter) against anaesthesia no more valid
INTRODUCTION

- increased incidence of chronic pulmonary disease
  - urbanization
- based on “disability adjusted life years” (DALY) lost
  - CPD ranked 12th in 1990
  - predicted to be 5th in 2020
Respiratory Failure

Type I
PaO₂ < 60mmHg
PaCO₂ normal or low

Type II
PaO₂ < 60mmHg
PaCO₂ > 50mmHg
CAUSES

Type I
1. ARDS
2. Asthma
3. Pulmonary edema
4. COPD
5. Interstitial fibrosis
6. Pneumonia
7. Pneumothorax
8. Pulmonary embolism
9. Pulmonary hypertension

Type II

C. Disorders of respiratory muscles or chest-wall
1. Muscular dystrophy
2. Polymyositis
3. Flail Chest

Disorders affecting signal transmission to the respiratory muscles
1. Myasthenia Gravis
2. Amyotrophic lateral sclerosis
3. Gullain-Barré syndrome

Neema PK. Indian J. Anaesth. 2003; 47 (5) : 360-6
INTRODUCTION

Pre-existing Respiratory Disease

Post-operative Pulmonary Complications (PPCs)
INTRODUCTION

- Incidence – 2 to 70%
  - pneumonia
  - aspiration pneumonitis
  - respiratory failure
  - re-intubation (within 48 hours)
  - prolonged ventilation
  - bronchospasm
  - pleural effusion
  - pneumothorax

PERI-OP MANAGEMENT

Clinical Assessment
- Functional Status

Evaluation of Risk Factors

Respiratory Preparation
- Medical / Physio-therapy

Intra-operative Monitoring

Anaesthetic Plan
CLINICAL ASSESSMENT
CLINICAL ASSESSMENT

- History of the Respiratory Disease
  - beginning of symptoms
  - previous acute respiratory failure ⇒ intensive care

- symptoms
  - cough
  - expectoration: mucous or purulent
  - dyspnea

- tobacco smoking
  - how long?
  - how many?
  ⇒ pack-years: complications for > 20
<table>
<thead>
<tr>
<th>Symptom / Signs</th>
<th>Clinical Correlate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Orthopnea, dyspnea</td>
<td>Pulmonary &amp; Cardiac Impairment</td>
</tr>
<tr>
<td>“happy wheezer”, “pink puffer”</td>
<td>COPD</td>
</tr>
<tr>
<td>Cyanosis</td>
<td>Right-left shunt, severe restriction</td>
</tr>
<tr>
<td>“barrel chest”, ↓ breath sounds</td>
<td>Emphysema</td>
</tr>
<tr>
<td>Prolonged expiration, wheeze</td>
<td>Asthma</td>
</tr>
<tr>
<td>Rough breath sounds</td>
<td>Pulmonary edema, pneumonia, secretion retention</td>
</tr>
<tr>
<td>Fine crackles</td>
<td>Pneumonia, atelectasis, fibrosis</td>
</tr>
<tr>
<td>Friction sounds</td>
<td>Pleuritis</td>
</tr>
<tr>
<td>Inspiratory stridor</td>
<td>interstitial edema</td>
</tr>
<tr>
<td>Expiratory stridor</td>
<td>COPD, asthma</td>
</tr>
</tbody>
</table>
CLINICAL ASSESSMENT

• Assessment of the Dyspnea Severity
  – patient’s ability to face the increase of the respiratory work in postoperative period
  – severity scores: Roizen’s scale
    • undiagnosed dyspnea of Grade II or above is to be further investigated
## ROIZEN’S CLASSIFICATION

<table>
<thead>
<tr>
<th>Grade</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade 0</td>
<td>No dyspnea while walking on the level at normal pace</td>
</tr>
<tr>
<td>Grade I</td>
<td>&quot;I am able to walk as far as I like, provided I take my time&quot;</td>
</tr>
<tr>
<td>Grade II</td>
<td>Specific street block limitation: &quot;I have to stop for a while after one or two blocks&quot;</td>
</tr>
<tr>
<td>Grade III</td>
<td>Dyspnea on mild exertion: &quot;I have to stop and rest going from the kitchen to the bathroom&quot;</td>
</tr>
<tr>
<td>Grade IV</td>
<td>Dyspnea at rest</td>
</tr>
</tbody>
</table>
Obesity
- alteration of ventilatory mechanics
  - ↓↑ chest wall compliance
  - decreased FRC
- increased sensibility of the respiratory centres to anaesthetics & analgesics
- risk of sleep apnea in case of:
  - diurnal drowsiness
  - nocturnal apnea and snoring
CLINICAL ASSESSMENT

• Chronic Malnutrition
  – reduced immunitary barriers
    • broncho-pulmonary infections
  – reduced muscle mass, metabolic deficiencies
    • respiratory muscular fatigue
LAB TESTING TO ESTIMATE RISK
CHEST X-RAY

• Chest X-ray - front and side views
  – degree of pulmonary distension
  – anomalies of the pleura and pulmonary parenchyma
  – presence of a pulmonary arterial hypertension
    • diameter of the descending part of the right pulmonary arterial ≥ 19 mm corresponding to a PAP ≥ 50/25 mmHg

Retro sternal space

Clear retro cardiac space

Flattening of the diaphragm
• 10 to 23.1% of preoperative chest radiographs abnormal
• only 1.3 to 3% had findings clinically important enough to influence management
• routine pre-op chest X-rays in patients < 70 years not indicated to predict PPCs
  – in the absence of other risk factors

SPIROMETRY

• **spirometry**
  – measuring pulmonary volumes & capacities
  – allows distinction between obstruction & restriction
  – morphology of loops \(\rightarrow\) severity of the obstruction

• **plethysmography**
  – measurement of the thoracic distension
The total amount of air expired as quickly as possible after taking the deepest possible breath.

Volume of air which can be forcibly exhaled from the lungs in the first second of a forced expiratory maneuver.

**VOLUME-TIME GRAPH**
FLOW-VOLUME LOOP

A. Normal

B. Emphysema

C. Unilateral main-stem bronchial obstruction

D. Fixed UAO

E. Variable extrathoracic UAO

F. Variable intrathoracic UAO

G. Restrictive parenchymal lung disease

H. Neuromuscular weakness
SPIROMETRY

• has value
  – before lung resection
  – determining candidacy for CABG
• value before extra-thoracic surgery -> unproven
• no better than clinical assessment by Hx / Ex
• not recommended for routine screening for risk of PPCs
• should be reserved for undiagnosed COPD

Qaseem A et al.. Ann Internal Med 2006; 144: 575-80
SPIROMETRY

• less informative than the clinical assessment and for the evaluation of the postoperative risk

• of interest:
  – to be sure that the preoperative respiratory preparation has reached the optimal result
  – if there are doubts after the clinical evaluation

de NINO et al. Chest 1997
• **Blood Urea Nitrogen (BUN)**
  – blood urea nitrogen ≥ 7.5 mmol/L (≥ 21 mg/dL) - a risk factor

• **Serum Albumin Levels**
  – low serum albumin level important predictor of PPCs
  – low levels defined as 30 – 39g/dL
  – 7% risk of PPCs with normal (>36g/dL)
  – 27.6% risk of PPCs with low albumin levels

• **Oropharyngeal Culture**

  Qaseem A *et al.*. Ann Internal Med 2006; 144: 575-80
RISK EVALUATION
PATIENT-RELATED RISK FACTORS

- **Age (>70 years)**
- **Chronic Lung Disease**
- **Smoking**
- **CHF**
- **Functional Dependence**
- **ASA Classification**
- **Obesity / OSA**
- **Asthma**
- **Others**

**COPD** most commonly identified risk factor

- OR 1.79

**modest increase in risk**

**total dependence** - inability to perform any activities of daily living (OR 2.51)

- ASA I: 1.2%
- ASA II: 5.4%
- ASA III: 11.4%
- ASA IV: 10.9%

**Obesity** - no increased risk

**OSA** - airway management

**modest ↑ increase PPCs risk:**

- impaired sensorium
- abnormal findings on chest examination
- alcohol use
- weight loss
PROCEDURE-RELATED RISK FACTORS

Surgical Site
Duration of Surgery
Anaesthetic Technique
Emergency Surgery

- aortic aneurysm repair thoracic
- prolonged surgery (>3 to 4 hours)
- modest increase in risk in GA OR 1.83
- significant risk factor OR 2.21
SCORING SYSTEMS

- developed to predict the risk of PPCs
  - all have low predictive values
  - important research tools for investigating strategies to decrease PPCs
## TORRINGTON’S SCORE

<table>
<thead>
<tr>
<th>Clinic</th>
<th>Point</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age &gt; 65 yrs</td>
<td>1</td>
</tr>
<tr>
<td>Obesity &gt; 150% of Ideal Weight</td>
<td>2</td>
</tr>
<tr>
<td>Smoker</td>
<td>1</td>
</tr>
<tr>
<td>Cough / Expectoration</td>
<td>1</td>
</tr>
<tr>
<td>Pulmonary Pathology</td>
<td>1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Spirometry</th>
<th>Point</th>
</tr>
</thead>
<tbody>
<tr>
<td>VC &lt; 50%</td>
<td>1</td>
</tr>
<tr>
<td>FEV&lt;sub&gt;1&lt;/sub&gt;/FVC 65-75%: 1</td>
<td>3</td>
</tr>
<tr>
<td>50-65%: 2</td>
<td></td>
</tr>
<tr>
<td>&lt;50%: 3</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Type of Surgery</th>
<th>Point</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abdominal</td>
<td>3</td>
</tr>
<tr>
<td>Thoracic</td>
<td>3</td>
</tr>
<tr>
<td>Other</td>
<td>1</td>
</tr>
</tbody>
</table>

- 0 – 3: Low risk
- 4 – 6: Moderate risk
- 6 – 13: High risk

Torrington KG, Henderson CJ. Chest. 1988;93(5): 946-51
## Summary of Risk Factors

<table>
<thead>
<tr>
<th>Patient-related Factors¹</th>
<th>Procedure-related Factors¹</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Supported by good evidence</strong></td>
<td><strong>Supported by fair evidence</strong></td>
</tr>
<tr>
<td>Advanced age</td>
<td>Aortic aneurysm repair</td>
</tr>
<tr>
<td>ASA class ≥2</td>
<td>Thoracic surgery</td>
</tr>
<tr>
<td>Congestive heart failure</td>
<td>Abdominal surgery</td>
</tr>
<tr>
<td>Functional dependency</td>
<td>Upper abdominal surgery</td>
</tr>
<tr>
<td>Chronic obstructive</td>
<td>Neurosurgery</td>
</tr>
<tr>
<td>pulmonary disease</td>
<td>Prolonged surgery</td>
</tr>
<tr>
<td></td>
<td>Head and neck surgery</td>
</tr>
<tr>
<td></td>
<td>Emergency surgery</td>
</tr>
<tr>
<td></td>
<td>Vascular surgery</td>
</tr>
<tr>
<td></td>
<td>Use of general anesthesia</td>
</tr>
<tr>
<td><strong>Supported by fair evidence</strong></td>
<td><strong>Perioperative transfusion</strong></td>
</tr>
<tr>
<td>Weight loss</td>
<td>Hip surgery</td>
</tr>
<tr>
<td>Impaired sensorium</td>
<td>Genitourinary/gynecologic surgery</td>
</tr>
<tr>
<td>Cigarette use</td>
<td></td>
</tr>
<tr>
<td>Alcohol use</td>
<td></td>
</tr>
<tr>
<td>Abnormal chest exam</td>
<td></td>
</tr>
</tbody>
</table>

**Good evidence against being a risk factor**

- Well-controlled asthma
- Obesity
- Hip surgery
- Genitourinary/gynecologic surgery

**Insufficient data**

- Obstructive sleep apnea²
- Esophageal surgery
- Poor exercise capacity

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¹ Please note that this classification is based on current medical knowledge and evidence available at the time of publication. Updates and revisions may occur as new research findings are reported.

² Obstructive sleep apnea is a condition that can affect an individual's breathing during sleep, leading to potential health issues. Esophageal surgery is a type of surgical procedure that involves the esophagus, usually due to conditions like Barrett's esophagus, esophageal strictures, or esophageal cancer.
PRE-OPERATIVE STRATEGIES
SMOKING EFFECTS

EVOLUTION OF THE FEV 1 ACCORDING TO THE AGE AND THE TOBACCO CONSUMPTION

% OF THE FEV 1 AT 20 YEARS

A = NON SMOKER, B = SMOKER WITHOUT COPD, C = SMOKER WITH COPD, D and E = LONGTERM SMOKING
SMOKING EFFECTS

RESPIRATORY RESISTANCES AFTER INTUBATION OF SMOKERS AND NON SMOKERS PATIENTS ACCORDING TO THE INDUCTION AGENT USED

(EAMES et al. Anesthesiology 1996)
SMOKING EFFECTS

EFFECTS OF SEVOFLURANE AND DESFLURANE ON THE PULMONARY RESISTANCES AFTER INTUBATION

According to GOFF et al, Anesthesiology 2000

SEVOFLURANE

DESFLURANE

TIME AFTER INDUCTION (in minutes)
SMOKING CESSATION

- controversial role in reducing PPCs
- benefits differently according to the delay of arrest

<table>
<thead>
<tr>
<th>Time</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>(before surgery)</td>
<td></td>
</tr>
<tr>
<td>12-24 hours</td>
<td>reduces the HbCO level, improving O$_2$-transport &amp; delivery to the tissues</td>
</tr>
<tr>
<td>48-72 hours</td>
<td>reduces the upper airway and bronchial reactivity</td>
</tr>
<tr>
<td>03-07 days</td>
<td>may increase the bronchorrhea, implying an increased risk</td>
</tr>
<tr>
<td>02-04 weeks</td>
<td>the risk is similar to the non smokers.</td>
</tr>
<tr>
<td>04-08 weeks</td>
<td>normalisation of the immune system with a reduction of the risk of infection but a possible increase of the respiratory risk.</td>
</tr>
<tr>
<td>08-12 weeks</td>
<td>a global reduction of the respiratory morbidity is observed.</td>
</tr>
</tbody>
</table>

PRE-OPERATIVE STEROIDS

• well-controlled asthma and COPD
  – not major risk factors for PPCs

• poorly controlled patients
  – benefit from pre-op steroids & bronchodilators
  – short course of high-dose pre-op steroids does not increase the risk of surgical complications
LUNG EXPANSION STRATEGIES

- include
  - incentive spirometry  (least labor intensive)
  - chest physical therapy
    - deep breathing exercises
    - cough
    - postural drainage
    - percussion and vibration
    - suctioning and ambulation
    - intermittent positive-pressure breathing
    - continuous positive-airway pressure  (in patients who cannot perform incentive spirometry)
INTRA-OPERATIVE STRATEGIES
“PROTECTIVE LUNG” STRATEGY

• ARDSNet study (NEJM 2000)
• low PEEP during anaesthesia -> increase atelectasis -> mortality and prolonged hospitalization
• moderate (but not high) PEEP -> decrease PPCs in at-risk patients

INTRA-OP BRONCHOSPASM

• detected by
  – wheezing
  ↗peak airway pressures (± unchanged plateau pressure)
  ↘exhaled tidal volumes
  – slowly rising waveform on the capnograph
  – failure of expiratory flow to return to baseline
• other causes to be ruled out
  – kinking, overinflated balloon, straining, secretions
INTRA-OP BRONCHOSPASM

- emergency surgery with active bronchospasm
  - should be treated aggressively
  - supplemental $O_2$
  - aerosolized $\beta_2$-agonists
  - intravenous glucocorticoids
  - guided by ABGs
ANESTHETIC TECHNIQUE

• neuraxial or regional anaesthesia for decreases PPCs
  – little supportive data.
• meta-analysis of 141 RCTs (GA vs neuraxial blockade)
• Complication rates with and without neuraxial blockade:
  – 3% and 5% for pneumonia (OR 0.61)
  – 0.5% and 0.8% for respiratory failure (OR 0.41)

Rodgers A et al. BMJ. 2000;321:1493
ANESTHETIC TECHNIQUE

- long-acting muscle relaxants (pancuronium)
- Residual neuromuscular
- 3 times more likely to develop PPCs

ANESTHETIC TECHNIQUE

• LMA decreases the risk of laryngeal spasm post-extubation
  – effect on other PPCs is probably minor

• volatile anaesthetics is theoretically attractive because of their bronchodilating properties.
  – no data that their use decreases PPCs compared with TIVA
ANESTHETIC TECHNIQUE

• opiate-sparing techniques may limit PPCs
  – multi-modal analgesia
  – local and regional anaesthesia

• thoracic epidural analgesia reduces respiratory complications and duration of ventilation in high-risk patients undergoing major surgery

Liu SS. Anesth Analg 2007;104:689-702
Nishimori M. Cochrane database syst review 2012; July 11
PERI-OPERATIVE CARE

• Nutritional support
  – malnutrition and hypoalbuminemia ↑ risk for PPCs
  – a meta-analysis & a multisite RCT
  – no proven advantage TPN in reducing PPCs

• Naso-gastric decompression
  – selective NG decompression -> significantly lower rate of pneumonia and atelectasis

• Pulmonary artery catheterization
• To prevent PPCs
  – evaluate all patients for risk factors
  – pre- & post-operative intervention in high risk patients
  – identify hypo-albuminemia
  – physiotherapy + selective NG insertion in high risk patients
  – spirometry & CXR appropriate only in previous COPD / asthma
THANK YOU