Pulmonary complications are a common form of postoperative morbidity experienced by patients who undergo general surgical abdominal procedures, thoracotomies and cardiac surgical procedures (See Table I).

This lecture will address the following issues:

- In most surgical procedures other than thoracic surgery, the majority causes of early perioperative morbidity are due to cardiac and vascular complications. However, postoperative pulmonary complications (PPC) (See Table II) are significant and will influence operative outcome.
- Assessment of pulmonary function is imperative. By being aware of preoperative limitations and pre-empting complications, outcomes are improved and hence postoperative recovery is hastened.
- General anaesthesia changes lung mechanics and therefore pulmonary function. Although pulmonary function may not essentially be compromised preoperatively, other patient factors may alter pulmonary function in the postoperative period. For example:
  - American Society of Anesthesiologists (ASA) rating (See Table VII)
  - Age
  - Prolonged duration of procedure
  - Surgical emergency as opposed to elective
- Evidence-based patient safety advisory singles out obstructive sleep apnoea and obstructive lung disease as causing an increased risk to the perioperative course.

Does preoperative pulmonary function impact on postoperative risk?

Pulmonary disease such as COPD is known to increase a patient's risk, but asthma and cigarette smoking do not. Pulmonary hypertension (RV systolic pressure > 35 mmHg) increases the risk of postoperative congestive heart failure, cardiac ischaemic events, dysrhythmias, strokes and respiratory failure (the most frequent morbidity). Interstitial lung disease and OSA may increase postoperative risk after abdominal procedures.

Preoperative pulmonary function testing

Most of the literature focuses on pulmonary testing in a subgroup of patients who have the worst pulmonary function, i.e. patients with lung pathology for thoracic operations.

“Anaesthesiologists are not gatekeepers”. In most situations the anaesthetist sees the patient at the end of the referral chain from family physician and finally to the surgeon. At each stage, there should be a discussion of the risks and benefits of the operation. The anaesthetist’s responsibility is to use preoperative assessment to identify those patients at elevated risk and to use that risk assessment to stratify perioperative management and focus resources on high-risk patients to improve their outcome.

Preoperative assessment of respiratory function cannot be done with a single test and the best assessment comes from a detailed history of the patient’s quality of life. It is useful to look at three independent areas: respiratory mechanics, gas exchange and cardiorespiratory interaction (Table III).
A patient that is unable to climb two flights of stairs is at a high risk for postoperative morbidity and mortality. Shaded area variables are clinically the most useful.

If a patient has a $\frac{\text{VO}_2}{\text{mg}} \text{max} > 15 \text{ ml/kg/minute}$, even in a high risk patient with FEV$_1 = 41\%$, there is no increased morality. It must be remembered that the six-minute walk shows an excellent correlation with $\frac{\text{VO}_2}{\text{mg}} \text{max}$. In patients with an estimated ppo $\frac{\text{VO}_2}{\text{mg}} \text{max} < 10 \text{ ml/kg/minute}$, 100% mortality has been reported.

Optimisation with spirometry and physiotherapy is beneficial in specific patients.

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### Table I: Incidence of pulmonary complications

<table>
<thead>
<tr>
<th></th>
<th>Cardiac surgery</th>
<th>Oesophagectomy</th>
<th>Abdominal surgery</th>
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<tbody>
<tr>
<td><strong>Incidence of pulmonary complications postoperatively</strong></td>
<td>40% Pneumonitis, bronchospasm and lobar collapse.</td>
<td>25-50% Mortality risk increases sevenfold if pulmonary complications develop. Pulmonary complications account for 40-60% mortality.</td>
<td>30% Risk of upper abdominal surgery increases by factor of 1.5. Highest risk is for abdominal aortic aneurysms.</td>
</tr>
<tr>
<td><strong>Return to normal</strong></td>
<td>Normal after 3 months.</td>
<td>Partially resolve 7 days. Complete after 6 weeks.</td>
<td>Transdiaphragmatic pressure ↓ almost 70% on day 1→ returns to normal in 1 week postoperatively.</td>
</tr>
</tbody>
</table>

### Table II: Postoperative pulmonary complications (PPCs)

- Pneumonia, bronchitis.
- Massive pulmonary collapse due to mucus plugging of a central airway.
- Pneumonitis.
- Atelectasis.
- Bronchospasm.
- Pulmonary embolism.
- Exacerbation of underlying lung disease.
- Respiratory failure and prolonged invasive or non-invasive ventilation.
- Obstructive sleep apnoea.
- ARDS.
- Specific cardiothoracic surgical problem:
  - Phrectic nerve injury.
  - Pleural effusion.
  - Bronchopleural fistula.
  - Sternal wound and empyema.
  - Gastro-oesophageal anastomotic leak.
  - Postoperative dysrhythmia.
  - Combination of the above.
General anaesthesia changes lung mechanics and therefore pulmonary function

Reduction of functional residual capacity (FRC) (See Table V) and an increase in closing volume (CV) (See Table VI) occur during general anaesthesia. This causes portions of the lung to have premature airway closure and atelectasis. The resulting mismatch of ventilation-perfusion causes hypoxaemia, trapping of secretions and pneumonitis.8

Table III: The three-legged stool of prethoractomy respiratory assessment

<table>
<thead>
<tr>
<th>Respiratory mechanics</th>
<th>Cardiopulmonary reserve</th>
<th>Lung parenchymal function, i.e. gas exchange capacity</th>
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<tbody>
<tr>
<td>FEV 1* (ppo &gt; 40%)</td>
<td>VO2_max* (&gt;= 15 ml/kg/minute)</td>
<td>DLCO* (ppo &gt; 40%)</td>
</tr>
<tr>
<td>MVV, RV/TLC, FVC</td>
<td>Stair climb &gt; 2 flights 6-minute walk Exercise SpO2 &lt; 4%</td>
<td>PaO2 &gt; 60 PaCO2 &lt; 45</td>
</tr>
</tbody>
</table>

* = most valid test, DLCO = diffusing capacity of the lung for carbon monoxide, VO2_max = maximum oxygen consumption, ppo = predictive postoperative outcome, MVV = maximum voluntary ventilation, RV/TLC = residual volume to total lung capacity ratio, FVC = forced vital capacity

Table IV: Summary of important points to consider in the initial pre-anaesthetic assessment prior to pulmonary surgery1

1. All patients: Exercise tolerance. ppoFEV 1%* Discuss postoperative analgesia, stop smoking
2. ppoFEV 1 < 40%: DLCO, V/Q scan, VO2 max
3. Cancer patients: the 4 Ms: mass effects, metabolic effects, metastases, medications
4. COPD patients: ABG, physiotherapy, bronchodilators
5. Increased renal risk: BUN, creatinine, Urea > 7.5 mmol/l is a risk factor3
6. Serum albumin: low <35 mmol/l is important 30-day predictor of postoperative morbidity and mortality.3
7. CXR: Should only be routine if known cardiopulmonary disease and > 50 years of age3

Table V: Factors that cause a reduction in functional residual capacity (FRC)

- General anaesthesia
- Lower abdominal surgery by 10-15%
- Upper abdominal procedures by 30%
- Thoracotomy and lung resection by 35%
- Supine position
- Obesity*
- Presence of ascites
- Development of peritonitis

* It seems logical that obesity should influence pulmonary function postoperatively, however statistical analysis shows that it does not increase risk for pulmonary complications postoperatively.2,13,14

Factors that may cause PPCs and increase operative risk

- Age (> 65 years) and ASA status of the patient does influence pulmonary risk postoperatively. (See Table VII).
- Nutritional status of patient is essential. Albumin < 35 mmol/l increases the risk.
- Site of the surgery, rather than the duration, does appear to affect the risk. Emergency procedures increase the risk.
- General versus regional anaesthesia only becomes significant if there is respiratory infection present preoperatively.
**Conclusion**

Pulmonary function, whether compromised preoperatively or intraoperatively, must impact on operative risk. Although cardiac and vascular complications are more common and hence should compromise operative outcomes to a greater extent, pulmonary function cannot be ignored by the surgical team.

**References**