Complications of Anaesthesia

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What are the complications of anaesthesia?

- Definition of Valchanov et al.
- Complication of anaesthesia

“Anything arising during or attributable to anaesthesia that was unexpected and created a potential or actual problem or difficulty or made the patient's care harder to deal with”

What are the complications of anaesthesia?

• In the simplest of terms

• Complications: something we do NOT want in our anaesthetics, for our patients or for ourselves

• We should do everything reasonably possible to avoid them and to mitigate their effects when they do occur
Complications of anaesthesia

• The true incidence: difficult to record accurately
  ▪ Many complications being ill-defined
  ▪ Recording of such events being heavily reliant on voluntary reporting

• The incidence rate of adverse events in hospitalised patients: 3–17%

• Ordinary standards of care: **CAN PREVENTABLE**

Complications of anaesthesia

• Today, anesthesia-related mortality in the USA:
  1.1 per million persons per year

• Common and rare causes of anesthesia-related morbidity and mortality: impact perioperative liability, especially in the setting of multiple comorbidities

Complication of anaesthesia: categorical by system
<table>
<thead>
<tr>
<th>Category</th>
<th>Problematic events</th>
<th>Potential clinical consequences</th>
<th>Contributory factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Airway</td>
<td>Difficulty in tracheal intubation</td>
<td>Dental trauma Soft tissue trauma Hypoxia</td>
<td>Difficult airway Inexperience Urgency</td>
</tr>
<tr>
<td></td>
<td>Cannot intubate, cannot oxygenate</td>
<td>Hypoxia Airway trauma Surgical airway Abandoned surgery Death</td>
<td>Difficult airway Inexperience Poor airway assessment</td>
</tr>
<tr>
<td>Respiratory</td>
<td>High airway pressures</td>
<td>Pulmonary barotrauma Pneumothorax</td>
<td>Inadequate muscle relaxation Obesity Bronchospasm Pneumoperitoneum</td>
</tr>
<tr>
<td></td>
<td>Endobronchial intubation</td>
<td>Hypoxia</td>
<td>Inexperience Failure to auscultate chest</td>
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<tr>
<td></td>
<td>Aspiration</td>
<td>Pneumonitis Prolonged ventilation</td>
<td>Unfasted patient Reflux</td>
</tr>
<tr>
<td></td>
<td>Needle injury to lung</td>
<td>Pneumothorax</td>
<td>Difficult central line insertion Inexperience</td>
</tr>
<tr>
<td>Category</td>
<td>Problematic events</td>
<td>Potential clinical consequences</td>
<td>Contributory factors</td>
</tr>
<tr>
<td>---------------------------</td>
<td>----------------------------</td>
<td>-----------------------------------------------------------------------------------------------</td>
<td>---------------------------------------------------------------</td>
</tr>
<tr>
<td>Cardiovascular</td>
<td>Hypotension</td>
<td>Myocardial ischaemia, Cardiac arrest, Brain injury</td>
<td>Bleeding, Sepsis, Neuraxial block, Hypovolaemia</td>
</tr>
<tr>
<td></td>
<td>Hypertension</td>
<td>Bleeding, Stroke, Vascular accidents such as anastamosis or aneurysm rupture</td>
<td>Light anaesthetic, Inadequate analgesia, Awareness</td>
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<tr>
<td>Central nervous system</td>
<td>Dural puncture</td>
<td>Postural headache</td>
<td>Difficult epidural or spinal, Inexperience</td>
</tr>
<tr>
<td></td>
<td>Misplaced epidural catheter</td>
<td>Intra- or postoperative pain</td>
<td>Difficult procedure, Long surgery, Inexperience</td>
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<tr>
<td></td>
<td>Damage to epidural vessel</td>
<td>Epidural haematoma, Paraplegia</td>
<td>Anticoagulation, Coagulopathy, Bleeding disorder</td>
</tr>
<tr>
<td></td>
<td>Failure to turn on vapouriser</td>
<td>Awareness, Psychological trauma</td>
<td>High-risk surgery, Comorbid patient, Distraction</td>
</tr>
<tr>
<td>Category</td>
<td>Problematic events</td>
<td>Potential clinical consequences</td>
<td>Contributory factors</td>
</tr>
<tr>
<td>--------------------------------</td>
<td>---------------------------------</td>
<td>--------------------------------------------------</td>
<td>------------------------------------------------</td>
</tr>
<tr>
<td>Peripheral nervous system</td>
<td>Intraneural injection</td>
<td>Peripheral nerve injury</td>
<td>Incorrect positioning of patient Inexperience</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Weakness</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pain</td>
<td></td>
</tr>
<tr>
<td>Drug related</td>
<td>Idiosyncratic drug reaction</td>
<td>Malignant hyperthermia</td>
<td>Patient factors Inadequate history taking</td>
</tr>
<tr>
<td></td>
<td>Drug administration error</td>
<td>Various unintended effects, for example, hypertension, neuromuscular blockade, awareness</td>
<td>Inadequate labelling Inattention Distraction</td>
</tr>
<tr>
<td></td>
<td>Tissue intravenous line</td>
<td>Lack of drug effect Compartment syndrome Tissue necrosis</td>
<td>Difficult i.v. access i.v. line in situ from the ward</td>
</tr>
</tbody>
</table>
Human error as a factor

In 1978, Cooper et al.

• Human errors: MORE common than pure equipment failure in PREVENTABLE incidents

• Inadvertent mistake: 82%
  ▪ Such as ‘syringe swaps’
  ▪ Accidental changes in fresh gas flow
  ▪ Unfamiliarity with clinical situations or equipment

## Human factors

| Induction of anaesthesia | • Drugs errors (mislabelling, syringe swaps, failure to mix drugs, underdosing due to lack of knowledge)  
| | • Distraction (by colleagues or by unexpected difficulty)  
| | • Timing (rushing, busy lists with multiple changes)  
| | • Fatigue  
| | • Seniority (unsupervised juniors, lack of knowledge) |

| Maintenance of anaesthesia | • Underdosing (due to cardiovascular instability, risk to fetus, inattention/judgement errors) |

| Emergence from anaesthesia | • Switching off anaesthetic agents too early due to poor communication or lack of knowledge  
| | • Failure to monitor neuromuscular blockade  
| | • Rushing and mistiming |

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Table 6. Contributing factors of the incident reports (n = 1996)

<table>
<thead>
<tr>
<th>Factor</th>
<th>n (%)</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inappropriate decision</td>
<td>405 (20.3)</td>
<td>4</td>
</tr>
<tr>
<td>Inexperience</td>
<td>510 (25.6)</td>
<td>1</td>
</tr>
<tr>
<td>Inadequate knowledge</td>
<td>69 (3.5)</td>
<td></td>
</tr>
<tr>
<td>Haste</td>
<td>330 (16.5)</td>
<td></td>
</tr>
<tr>
<td>Tiredness</td>
<td>32 (1.6)</td>
<td></td>
</tr>
<tr>
<td>Personnel’s illness</td>
<td>4 (0.2)</td>
<td></td>
</tr>
<tr>
<td>Inadequate personnel</td>
<td>62 (3.1)</td>
<td></td>
</tr>
<tr>
<td>Communication defect</td>
<td>64 (3.2)</td>
<td></td>
</tr>
<tr>
<td>Unfamiliar to environment</td>
<td>14 (0.7)</td>
<td></td>
</tr>
<tr>
<td>Emergency condition</td>
<td>422 (21.1)</td>
<td>3</td>
</tr>
<tr>
<td>Inadequate preoperative evaluation</td>
<td>432 (21.6)</td>
<td>2</td>
</tr>
<tr>
<td>Inadequate preparation</td>
<td>243 (12.2)</td>
<td></td>
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<tr>
<td>Inadequate equipment</td>
<td>38 (1.9)</td>
<td></td>
</tr>
<tr>
<td>Ineffective equipment</td>
<td>71 (3.6)</td>
<td></td>
</tr>
<tr>
<td>No monitor</td>
<td>33 (1.7)</td>
<td></td>
</tr>
<tr>
<td>Ineffective monitor</td>
<td>36 (1.8)</td>
<td></td>
</tr>
<tr>
<td>Error in drug label</td>
<td>17 (0.9)</td>
<td></td>
</tr>
<tr>
<td>No recovery room</td>
<td>3 (0.2)</td>
<td></td>
</tr>
<tr>
<td>No bed in intensive care unit</td>
<td>59 (3.0)</td>
<td></td>
</tr>
<tr>
<td>Long waiting for blood transfusion etc.</td>
<td>30 (1.5)</td>
<td></td>
</tr>
<tr>
<td>etc.</td>
<td>386 (19.3)</td>
<td></td>
</tr>
</tbody>
</table>

Data are expressed as number (%)

Complication of anaesthesia

• Preoperative
• Intraoperative
• Postoperative
<table>
<thead>
<tr>
<th>Phase</th>
<th>n</th>
<th>(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preinduction</td>
<td>60</td>
<td>3.0</td>
</tr>
<tr>
<td>Induction</td>
<td>445</td>
<td>22.3</td>
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<tr>
<td>Maintenance</td>
<td>678</td>
<td>34.0</td>
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<tr>
<td>Emergence</td>
<td>111</td>
<td>5.6</td>
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<tr>
<td>Recovery</td>
<td>191</td>
<td>9.6</td>
</tr>
<tr>
<td>Post recovery (in 24 hr)</td>
<td>304</td>
<td>15.2</td>
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</table>

<table>
<thead>
<tr>
<th>Location</th>
<th>n</th>
<th>(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Induction room</td>
<td>7</td>
<td>0.4</td>
</tr>
<tr>
<td>Intensive care unit</td>
<td>91</td>
<td>4.6</td>
</tr>
<tr>
<td>Operating room</td>
<td>1220</td>
<td>61.1</td>
</tr>
<tr>
<td>Recovery room</td>
<td>188</td>
<td>9.4</td>
</tr>
<tr>
<td>Emergency unit</td>
<td>4</td>
<td>0.2</td>
</tr>
<tr>
<td>Delivery</td>
<td>1</td>
<td>0.1</td>
</tr>
<tr>
<td>Dental</td>
<td>1</td>
<td>0.1</td>
</tr>
<tr>
<td>Ward</td>
<td>216</td>
<td>10.8</td>
</tr>
<tr>
<td>Imaging</td>
<td>7</td>
<td>0.4</td>
</tr>
<tr>
<td>Transfer period</td>
<td>4</td>
<td>0.2</td>
</tr>
<tr>
<td>Other location</td>
<td>4</td>
<td>0.2</td>
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</tbody>
</table>

Data are expressed as number (%)
Focus topic

• Respiratory complication
  • Desaturation
  • Difficult intubation

• Cardiovascular complication
  • Arrhythmias
  • Myocardial infarction
Respiratory complication

Desaturation

Difficult intubation
Respiratory complications

• Most common complications after major surgery
  ▪ Patient well-being and outcome

• Non-obstetric and non-cardiac surgery: increased risk during surgery 14.5%

• Worsening outcomes and prolonged hospital stay
Scenario

• During a caesarean section under spinal anaesthesia, a fit 23-year-old primigravida complains of tingling in the fingers and difficulty breathing. The $\text{SpO}_2$ falls from 97% to 88%. What are the most likely causes and what action would you take?
Desaturation

• Oxygen desaturation
  ▪ $\text{SpO}_2 < 90\%$ for at least 3 min OR
  ▪ $\text{SpO}_2 < \text{or} = 85\%$

The Thai Anesthesia Incident Monitoring Study (Thai AIMS) of Desaturation: An Analysis of 1,996 Incident Reports

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** Department of Anesthesiology, Songklanagarind Hospital, Prince of Songkla University, Songkhla
*** Department of Anesthesiology, Chiang Mai University, Chiang Mai
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****** Department of Anesthesiology, Ramathibodi Hospital, Mahidol University, Bangkok

Background and Rationale: The present study is a part of the Multicentered Study of Model of Anesthesia related Adverse Events in Thailand by Incident Report (The Thai Anesthesia Incident Monitoring Study or Thai AIMS). The objective of the present study was to determine the frequency distribution, outcomes, contributory factors, and factors minimizing incident.

Material and Method: The present study is a prospective descriptive research design. The authors extracted relevant data from the incident reports on oxygen desaturation from the Thai AIMS database and analyzed during the study period between January and June 2007.

Results: From the relevant 445 incidents, most of the incidents (89%) occurred in patients receiving general anesthesia. The incidence in patients receiving regional anesthesia was 4.0%. The events mostly occurred in patients aged between 16-65 years (52.8%). Most of the events (76%) took place in the operating theater during the induction period (30.1%). More than 81% of the patients experienced severe oxygen desaturation (SpO2 < 85%). There were 55 patients (12.4%) who had unplanned ICU admission and 2 patients (0.4%) who had unplanned hospital admission. Factors that may relate to the incident involve combined factors (50.8%). Anesthetic factors were found to involve 38.4% of incidents. The common contributing factors that might lead to the incidents were inexperienced (57.5%), inappropriate decision (56.2%), and haste (23.8%). For factors minimizing incident, the important factors were vigilance (86.3%), experienced in that tropic (71.2%), and experienced assistance (54.8%). Quality assurance activity was the most common suggestive corrective strategy (79.1%). The others were improvement of supervision (47.2%) and guideline practice (46.5%).
Table 2. Place and period of anesthesia where oxygen desaturation happened

<table>
<thead>
<tr>
<th>Place</th>
<th>n</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating theater</td>
<td>335</td>
<td>75.3</td>
</tr>
<tr>
<td>Post-anesthesia care unit</td>
<td>83</td>
<td>18.7</td>
</tr>
<tr>
<td>Ward</td>
<td>16</td>
<td>3.5</td>
</tr>
<tr>
<td>ICU</td>
<td>5</td>
<td>1.1</td>
</tr>
<tr>
<td>Transfer period</td>
<td>3</td>
<td>0.7</td>
</tr>
<tr>
<td>Induction room</td>
<td>2</td>
<td>0.4</td>
</tr>
<tr>
<td>Imaging suite</td>
<td>2</td>
<td>0.4</td>
</tr>
<tr>
<td>Others</td>
<td>1</td>
<td>0.2</td>
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<table>
<thead>
<tr>
<th>Period</th>
<th>n</th>
<th>%</th>
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<tr>
<td>Preinduction</td>
<td>9</td>
<td>2.0</td>
</tr>
<tr>
<td>Induction</td>
<td>134</td>
<td>30.1</td>
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<tr>
<td>Maintenance</td>
<td>122</td>
<td>27.4</td>
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<tr>
<td>Emergence</td>
<td>73</td>
<td>16.4</td>
</tr>
<tr>
<td>PACU</td>
<td>85</td>
<td>19.1</td>
</tr>
<tr>
<td>Post-recovery (24 hours)</td>
<td>23</td>
<td>5.2</td>
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</table>

PACU postanesthesia care unit

Factors that may related to desaturation

• Patient factors
• Surgical factors
• Anaesthesia factors
Factors that may related to desaturation

<table>
<thead>
<tr>
<th>Patients factors</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anatomy difficult intubation</td>
<td>31</td>
</tr>
<tr>
<td>Underlying lung pathology; pneumonia, atelectasis, asthma, etc</td>
<td>30</td>
</tr>
<tr>
<td>Obesity</td>
<td>29</td>
</tr>
<tr>
<td>Secretion</td>
<td>25</td>
</tr>
<tr>
<td>Airway edema/injury/obstruction</td>
<td>18</td>
</tr>
</tbody>
</table>

Factors that may related to desaturation

<table>
<thead>
<tr>
<th>Surgical factors</th>
<th>n</th>
</tr>
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<tbody>
<tr>
<td>Airway surgery</td>
<td>17</td>
</tr>
<tr>
<td>Massive blood loss</td>
<td>10</td>
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</tbody>
</table>
Factors that may related to desaturation

<table>
<thead>
<tr>
<th>Anaesthesia factors</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Laryngospasm</td>
<td>70</td>
</tr>
<tr>
<td>Delayed emergency from drug (55)/muscle relaxant (13)</td>
<td>68</td>
</tr>
<tr>
<td>Inexperienced personnel in airway management</td>
<td>21</td>
</tr>
<tr>
<td>Hypoventilation from sedation</td>
<td>12</td>
</tr>
<tr>
<td>Airway obstruction from sedation</td>
<td>14</td>
</tr>
<tr>
<td>Accidental extubation</td>
<td>7</td>
</tr>
<tr>
<td>Airway obstruction from other causes; multiple attempt to intubation (3),</td>
<td>5</td>
</tr>
<tr>
<td>toxic substance (1), retained gauze packing (1)</td>
<td></td>
</tr>
<tr>
<td>Improper size of endotracheal tube/ LMA</td>
<td>5</td>
</tr>
<tr>
<td>Air embolism from intravenous fluid bag</td>
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</tbody>
</table>

Factors that may related to desaturation

<table>
<thead>
<tr>
<th>Factors</th>
<th>Adjusted odds ratio (95%CI)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age &lt; 5 yr</td>
<td>9.3 (5.4-16.0)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>ASA physical status</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1-2</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>3-5</td>
<td>3.1 (2.2-4.3)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>History of URI</td>
<td>10 (1.9-51.6)</td>
<td>0.01</td>
</tr>
<tr>
<td>History of asthma</td>
<td>2.9 (1.0-9.5)</td>
<td>0.04</td>
</tr>
<tr>
<td>General anesthesia</td>
<td>4.0 (2.4-6.7)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Anesthesia duration</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt; 30 min</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>31-90 min</td>
<td>1.9 (1.2-3.0)</td>
<td>0.005</td>
</tr>
<tr>
<td>91-150 min</td>
<td>2.2 (1.3-3.6)</td>
<td>0.002</td>
</tr>
<tr>
<td>&gt; 150 min</td>
<td>2.0 (1.2-3.4)</td>
<td>0.005</td>
</tr>
</tbody>
</table>

Abbreviation: URI = upper respiratory tract infection

<table>
<thead>
<tr>
<th>Source of problem</th>
<th>Common problem</th>
</tr>
</thead>
</table>
| **A. AIRWAY**     | • An obstructed airway prevents oxygen reaching the lungs  
                    • The tracheal tube can be misplaced e.g. in the oesophagus  
                    • Aspirated vomit can block the airway |
| **B. BREATHING**  | • Inadequate breathing prevents enough oxygen reaching the alveoli  
                    • Severe bronchospasm may not allow enough oxygen to reach the lungs nor carbon dioxide to be removed from the lungs  
                    • A pneumothorax may cause the affected lung to collapse  
                    • High spinal anaesthesia may cause inadequate breathing |
| **C. CIRCULATION**| • Circulatory failure prevents oxygen from being transported to the tissues  
                         • Common causes include hypovolemia, abnormal heart rhythm or cardiac failure |
| **D. DRUGS**      | • Deep anaesthesia may depress breathing and circulation  
                         • Many anaesthetic drugs cause a drop in blood pressure  
                         • Muscle relaxants paralyse the muscles of respiration  
                         • Anaphylaxis can cause bronchospasm and low cardiac output |
| **E. EQUIPMENT**  | • Problems with the anaesthetic equipment include disconnection or obstruction of the breathing circuit  
                         • Problems with oxygen supply include an empty cylinder or oxygen concentrator not working  
                         • Problems with the monitoring equipment include battery failure in the oximeter or a faulty probe |
Whenever the patient has low saturations;

• Administer high flow oxygen

• Consider ‘A B C D E’

  A - airway clear?

  B - breathing adequately?

  C - circulation working normally?

  D - drugs causing a problem?

  E - equipment working properly?
A – Is the airway clear?

• Is the patient breathing quietly without signs of obstruction?

• Are there signs of laryngospasm?
  ▪ Mild laryngospasm – high pitched inspiratory noise
  ▪ Severe laryngospasm – silent, no gas passes between the vocal cords

• Is there any vomit or blood in the airway?

• Is the tracheal tube in the right place?
A – Is the airway clear?

**Action**

- Ensure that there is no obstruction. If breathing via a facemask - chin lift, jaw thrust
- Consider an oropharyngeal or nasopharyngeal airway
- Check for laryngospasm and treat if necessary
- Check the tracheal tube/LMA - if any doubt about the position, remove and use a facemask
- Suction the airway to clear secretions
- Consider waking the patient up if you have difficulty maintaining the airway immediately after induction of anaesthesia
- Consider intubation
- If you ‘can’t intubate, can’t ventilate’ an emergency surgical airway may be required
B - Is the patient breathing adequately?

Look, listen and feel:

• Are the chest movements and tidal volume adequate?

• Listen to both lungs
  ▪ Is there normal bilateral air entry?
  ▪ Are the breath sounds normal?
  ▪ Any wheeze or added sounds?

• Is the chest movement symmetrical?

• Is anaesthesia causing respiratory depression?

• Is there a high spinal causing respiratory distress?
B - Is the patient breathing adequately?

**Action**

- Assist ventilation with good tidal volumes to expand both lungs until the problem is diagnosed and treated appropriately.

- If there is sufficient time, consider a chest X-ray to aid diagnosis.
C - Is the circulation normal?

• Feel for a pulse and look for signs of life, including active bleeding from the surgical wound
• Check the blood pressure
• Check the peripheral perfusion and capillary refill time
• Observe for signs of excessive blood loss in the suction bottles or wound swabs
• Is anaesthesia too deep?
• Is there a high spinal block?
• Is venous return impaired by compression of the vena cava (gravid uterus, surgical compression)
• Is the patient in septic or cardiac shock?
C - Is the circulation normal?

Action

• If the blood pressure is low, correct it

• Check for hypovolaemia

• Give IV fluids as appropriate (normal saline or blood as indicated)

• Consider head down or leg up position, or in the pregnant mother, left lateral displacement

• Consider a vasoconstrictor such as ephedrine or phenylephrine

• If the patient has suffered a cardiac arrest, commence cardiopulmonary resuscitation (CPR) and consider reversible causes
D – Drug effects

• Excessive halothane (or other volatile agent) causes cardiac depression

• Muscle relaxants will depress the ability to breathe if not reversed adequately at the end of surgery

• Opioids and other sedatives may depress breathing

• Anaphylaxis causes cardiovascular collapse, often with bronchospasm and skin flushing (rash)
D – Drug effects

Action

• Look for an adverse drug effect

• In anaphylaxis
  ▪ Stop administering the causative agent
  ▪ Administer 100% oxygen
  ▪ Give intravenous saline starting with a bolus of 10ml/kg
  ▪ Administer adrenaline and consider giving steroids
  ▪ Bronchodilators
  ▪ Antihistamine
E - Is the equipment working properly?

- Is there a problem with the oxygen delivery system to the patient?
- Does the oximeter show an adequate pulse signal?
E - Is the equipment working properly?

Action

• Check for obstruction or disconnection of the breathing circuit or tracheal tube
• Check that the oxygen cylinder is not empty
• Check that the oxygen concentrator is working properly
• Check that the central hospital oxygen supply is working properly
• Change the probe to another site; check that it is working properly by trying it on your own finger
Table 3. Outcomes after the events of oxygen desaturation

<table>
<thead>
<tr>
<th>Outcome</th>
<th>n</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Immediate outcome (&lt; 24 hours)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Major physiological change</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reintubation</td>
<td>17</td>
<td>3.8</td>
</tr>
<tr>
<td>Myocardial ischemia/infarction</td>
<td>3</td>
<td>0.7</td>
</tr>
<tr>
<td>Cardiac arrest</td>
<td>29</td>
<td>6.5</td>
</tr>
<tr>
<td>Death</td>
<td>29</td>
<td>6.5</td>
</tr>
<tr>
<td>Cancelled operation</td>
<td>9</td>
<td>2.0</td>
</tr>
<tr>
<td><strong>Unplanned ICU admission</strong></td>
<td>55</td>
<td>12.1</td>
</tr>
<tr>
<td>Unplanned hospital admission</td>
<td>2</td>
<td>0.4</td>
</tr>
<tr>
<td><strong>Long term outcome (&gt; 24 hours)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prolonged ventilatory support</td>
<td>2</td>
<td>0.4</td>
</tr>
<tr>
<td>Brain death</td>
<td>1</td>
<td>0.2</td>
</tr>
<tr>
<td>Death</td>
<td>1</td>
<td>0.2</td>
</tr>
</tbody>
</table>

Scenario

• During a caesarean section under spinal anaesthesia, a fit 23-year-old primigravida complains of tingling in the fingers and difficulty breathing. The SpO₂ falls from 97% to 88%. What are the most likely causes and what action would you take?
• Give 100% oxygen. Check ABCDE

• A – check that the airway is clear

• B - assess breathing. A high spinal may paralyse the muscles of respiration. If breathing is inadequate, ventilate the patient and induce anaesthesia and intubate. Ventilate until the block wears off

• C – check the blood pressure – hypotension is likely. Treat with left lateral tilt, IV fluids and vasopressors

• D – check the height of the block. Look for signs of a very high block - difficulty breathing, whispering rather than talking, weak arms and numbness on the shoulders. All indicate the nerves to the diaphragm are becoming blocked. This will make it impossible for the patient to breathe. If the block is not this high, the patient can talk in a normal voice and move their arms normally, but breathing still feels difficult due to the intercostal paralysis, normally the patient can breathe safely using their diaphragm.

• E – always ensure that equipment is ready in case this complication occurs.
Scenario

- An obese man (body mass index 40) sustained closed head injury, lung contusions, and C-spine injury after a fall from a tree. Tracheal intubation was performed by paramedics at the scene, and the patient was transported to the hospital. Three days later, the patient had satisfactory neurologic and respiratory recovery, but the neck collar was still in place. After meeting extubation criteria, his trachea was extubated. The patient immediately developed severe respiratory difficulty, and his oxygen saturation started to drop. Attempts to ventilate the lungs with a facemask were unsuccessful. As the patient lost consciousness, laryngoscopy was performed after removing the neck collar and applying in-line head stabilization. No laryngeal structures could be visualized.
Loss of airway/difficult intubation

• The inability to intubate or mask ventilate: one of the most feared complications in anesthesiology

• Early anesthetics: spontaneously breathing patients inhaling anesthetic vapor → completely obstruct or aspirate gastric contents and die

• The utilization of endotracheal tubes began in earnest with the published work of Meltzer, Auer and Elsberg in 1909

Loss of airway/difficult intubation

1913, Janeway;

- Using the laryngoscope to assist intubating the trachea
- Since that time, a plethora of tools invented to aid intubation has improved the ability to intubate
- Until now, no device carries a 100% guarantee of success

Burkle CM, Zepeda FA, Bacon DR, Rose SH. A historical perspective on use of the laryngoscope as a tool in anesthesiology. Anesthesiology 2004;100:1003–6
Direct speculum for catheterizing the trachea. (1 ) Press button for illuminating the lamp. (2 ) Lamp. (3 and 4 ) Direction of vision. (5 and 6 ) Direction taken by the catheter. (7 ) Handle containing two dry cells. From Janeway 8; reprinted with permission.

Burkle CM, Zepeda FA, Bacon DR, Rose SH. A historical perspective on use of the laryngoscope as a tool in anesthesiology. Anesthesiology 2004;100:1003–6
Loss of airway/difficult intubation

• Respiratory events → 17% of Closed Claims outcomes with **BRAIN DAMAGE** and **DEATH** being the most serious

• 27% → **DIFFICULT INTUBATION**
  • 67% → originally assessed as having a ‘**NORMAL AIRWAY**’

• No more than **THREE** attempts at standard direct laryngoscopy
DIFFICULT AIRWAY ALGORITHM

1. Assess the likelihood and clinical impact of basic management problems:
   - Difficulty with patient cooperation or consent
   - Difficult mask ventilation
   - Difficult supraglottic airway placement
   - Difficult laryngoscopy
   - Difficult intubation
   - Difficult surgical airway access

2. Actively pursue opportunities to deliver supplemental oxygen throughout the process of difficult airway management.

3. Consider the relative merits and feasibility of basic management choices:
   - Awake intubation vs. intubation after induction of general anesthesia
   - Non-invasive technique vs. invasive techniques for the initial approach to intubation
   - Video-assisted laryngoscopy as an initial approach to intubation
   - Preservation vs. ablation of spontaneous ventilation

4. Develop primary and alternative strategies:

**AWAKE INTUBATION**
- Airway approached by Noninvasive intubation
  - Succeed*
  - FAIL
    - Cancel Case
    - Consider feasibility of other options*(a)
    - Invasive airway access*(b)*

**INTUBATION AFTER INDUCTION OF GENERAL ANESTHESIA**
- Initial intubation attempts successful*
- Initial intubation Attempts UNSUCCESSFUL
  - FROM THIS POINT ONWARDS CONSIDER:
    1. Calling for help.
    2. Returning to spontaneous ventilation.
    3. Awakening the patient.

**FACE MASK VENTILATION ADEQUATE**

**FACE MASK VENTILATION NOT ADEQUATE**
- CONSIDER/ATTEMPT SGA
  - SGA ADEQUATE*
  - SGA NOT ADEQUATE OR NOT FEASIBLE

**NONEMERGENCY PATHWAY**
- Ventilation adequate, intubation unsuccessful
  - Alternative approaches to intubation*(c)
    - Successful Intubation*
    - FAIL after multiple attempts
      - Invasive airway access*(b)*
      - Consider feasibility of other options*(a)

**EMERGENCY PATHWAY**
- Ventilation not adequate, intubation unsuccessful
  - Call for help
  - Emergency noninvasive airway ventilation*(e)
    - Successful ventilation*
    - FAIL
    - Invasive invasive airway access*(b)*
    - Consider feasibility of other options*(a)
    - Awaken patient*(d)
<table>
<thead>
<tr>
<th>Techniques for Difficult Intubation</th>
<th>Techniques for Difficult Ventilation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Awake intubation</td>
<td>Intratracheal jet stylet</td>
</tr>
<tr>
<td>Blind intubation (oral or nasal)</td>
<td>Invasive airway access</td>
</tr>
<tr>
<td>Fiberoptic intubation</td>
<td>Supraglottic airway</td>
</tr>
<tr>
<td>Intubating stylet or tube-changer</td>
<td>Oral and nasopharyngeal airways</td>
</tr>
<tr>
<td>Supraglottic airway as an intubating conduit</td>
<td>Rigid ventilating bronchoscope</td>
</tr>
<tr>
<td>Laryngoscope blades of varying design and size</td>
<td>Two-person mask ventilation</td>
</tr>
<tr>
<td>Light wand</td>
<td></td>
</tr>
<tr>
<td>Videolaryngoscope</td>
<td></td>
</tr>
</tbody>
</table>
Video Laryngoscopy

- Video-assisted techniques: used for decades in many surgical disciplines: replaced open approaches
- In 1996, Levitan introduced a video camera attached to a head ring (Airway Cam)
- With this technique, intubation performed with a standard laryngoscope: displayed on a video monitor
Indications for Video Laryngoscopy

• Airway pathology, difficult airway (e.g., trauma, tumor, previous surgery)

• Immobilization of the cervical spine

• Limited spatial conditions

• Education, teaching

• Documentation
Limitation of Video Laryngoscope

• The common causes of failed VL include
  ▪ Severely limited month opening (<2cm)
  ▪ Severely limited neck movement
  ▪ Severe upper airway distortion caused by malignant or extensive oropharyngeal infection
  ▪ Blurred vision by secretion, blood or vomitus
Limitation of Video Laryngoscope

• Awake fiberoptic intubation remain the GOLD STANDARD for patients with a predicted difficult airway especially in difficult intubation and mask ventilation
## The CCAM Approach to Laryngoscopy

### Know your enemy
If there is time, assess the airway using the ‘Three-column model’

### Choose your weapons
Based on whether there is a posterior, middle or anterior column problem
Knowing which devices need introducers

### Prepare your patient
Ear to sternal notch (sniffing +/- ramping), apnoeic oxygenation, suction

### Prepare your team
Role delineation, drugs, equipment, back-up plans

### Stage 1: Laryngeal exposure
- Epiglottoscopy with suction
- Lift epiglottis (direct or indirect)
- Lift scope in line with handle
- +/- Bimanual laryngoscopy
- +/- Increased head elevation

### Stage 2: Tube/bougie to glottis
- **Straight/McCoy/Polio/Standard Video:**
  - Advance tube/bougie from below into line-of-sight
  - Introducer optional
- **Angulated Video:**
  - Tilt device so glottis in top half of monitor
  - Angulated introducer mandatory (non-channelled)
  - No introducer (channelled blade)

### Stage 3: Tube into trachea
- Withdraw stylet if used
- +/- 90° Right turn for Rings
- +/- Bimanual laryngoscopy
- +/- 90° Left turn if tube not passing over bougie
  (Bougie Left Turn = BLT)
How to successful intubate with VLs

• Step 1: optimal VLs insertion to view the glottis
  • Midline
  • Optimal glottic view
  • External laryngeal pressure
  • Increase head elevation
How to successful intubate with VLs

• Step 2: Delivery the ETT to the glottic opening
  • Use of intubating stylet and tracheal introducer
  • Tilt device down, keep glottis in upper haft of the screen
How to successful intubate with VLs

• Step 3 : Advancing the ETT in to trachea
  • Turing ETT 90 degrees clockwise
  • Reverse loading ETT
  • GEB or flexible bronchoscopcy
## Devices with a Macintosh-like blade

<table>
<thead>
<tr>
<th>Brand</th>
<th>Model</th>
<th>Monitor Size</th>
<th>Resolution</th>
<th>Camera Chip</th>
<th>Illumination</th>
<th>Multimedia</th>
<th>Accu</th>
<th>IP Prot. Class</th>
<th>Weight (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>C-MAC</td>
<td>(Fig. 25-T1)</td>
<td>7 inch</td>
<td>800 x 400</td>
<td>CMOS</td>
<td>LED</td>
<td>SD card for picture, video recording</td>
<td>Lithium-Ion</td>
<td>IP 54</td>
<td>1500</td>
</tr>
<tr>
<td>C-MAC PM</td>
<td>(Fig. 25-T2)</td>
<td>2.4 inch</td>
<td>320 x 240</td>
<td>CMOS</td>
<td>LED</td>
<td>—</td>
<td>Lithium-Ion</td>
<td>IP X8</td>
<td>180 (w/o blade)</td>
</tr>
<tr>
<td>McGrath MAC</td>
<td>(Fig. 25-T3)</td>
<td>2.5 inch</td>
<td>NA</td>
<td>CMOS</td>
<td>LED</td>
<td>—</td>
<td>Lithium-Ion</td>
<td>IP X7</td>
<td>200</td>
</tr>
<tr>
<td>A.P. Advance</td>
<td>(Fig. 25-T4)</td>
<td>3.5 inch</td>
<td>320 x 240</td>
<td>CMOS</td>
<td>LED</td>
<td>Video output</td>
<td>Batteries (1 x AA)</td>
<td>IP 67/monitor 33</td>
<td>435</td>
</tr>
<tr>
<td>Truvew PCD</td>
<td>(Fig. 25-T5)</td>
<td>5 inch</td>
<td>640 x 480</td>
<td>CCD (clip-on)</td>
<td>LED</td>
<td>USB-2, RCA video output</td>
<td>Batteries (rechargeable)</td>
<td>IP X0</td>
<td>NA</td>
</tr>
</tbody>
</table>

**Brand**: Karl Storz, Karl Storz, Aircraft Medical, Medical/distr. by LMA, Truphatek Intl.
Devices with an extra-curved blade

<table>
<thead>
<tr>
<th>Highly Curved Blades (Obligatory Indirect)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Brand</strong></td>
</tr>
<tr>
<td><strong>Manufacturer</strong></td>
</tr>
<tr>
<td><strong>Monitor size</strong></td>
</tr>
<tr>
<td><strong>Resolution</strong></td>
</tr>
<tr>
<td><strong>Camera chip</strong></td>
</tr>
<tr>
<td><strong>Illumination</strong></td>
</tr>
<tr>
<td><strong>Multimedia</strong></td>
</tr>
<tr>
<td><strong>Accu</strong></td>
</tr>
<tr>
<td><strong>IP Prot. class</strong></td>
</tr>
<tr>
<td><strong>Weight (g)</strong></td>
</tr>
</tbody>
</table>
Devices with a channelled blade

<table>
<thead>
<tr>
<th>Device</th>
<th>Brand</th>
<th>Manufacturer</th>
<th>Monitor size</th>
<th>Resolution</th>
<th>Camera chip</th>
<th>Illumination</th>
<th>Multimedia</th>
<th>Accu</th>
<th>IP Prot. class</th>
<th>Weight (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pentax AWS (see Fig. 25-T11)</td>
<td>Pentax/distr. by Ambu</td>
<td>King Systems</td>
<td>2.4 inch</td>
<td>NA</td>
<td>CCD</td>
<td>LED</td>
<td>NTSC video output</td>
<td>Batteries (2 x AA)</td>
<td>IP X7</td>
<td>375</td>
</tr>
<tr>
<td>King Vision (see Fig. 25-T12)</td>
<td></td>
<td>Prodol</td>
<td>2.4 inch</td>
<td>320 x 240</td>
<td>CMOS</td>
<td>LED</td>
<td>Video output</td>
<td>Batteries (3 x AAA)</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Airtraq (Fig. 25-T13)</td>
<td></td>
<td>Venner Medical/distr. by LMA</td>
<td>—</td>
<td>—</td>
<td>None</td>
<td>LED</td>
<td>Clip-on camera</td>
<td>Batteries (3 x AAA)</td>
<td>IP 67/monitor 33</td>
<td>435</td>
</tr>
<tr>
<td>A.P. Advance DAB (Fig. 25-T14)</td>
<td></td>
<td></td>
<td>3.5 inch</td>
<td>320 x 240</td>
<td>CMOS</td>
<td>LED</td>
<td>Video output</td>
<td>Batteries (1 x AA)</td>
<td>NA</td>
<td>NA</td>
</tr>
</tbody>
</table>
Different in design and shapes
Different in efficacies

• **NO SINGLE DEVICE THAT IS BETTER** than others in all conditions

• Each device has **UNIQUE PROPERTIES**: advantageous in some conditions, but limiting in other situations

• Even design modification may significantly change the success rate, intubation time and use of adjunct maneuvers

• To get the best out of VLs, anaesthesiologist must select the devices according patient’s airway anatomy and pathology

F. E. Kelly, T. M. Cook; Seeing is believing: getting the best out of videolaryngoscopy, *BJA: British Journal of Anaesthesia*, Volume 117, Issue suppl_1, 1 September 2016, Pages i9–i13,
Primary and secondary airway curves
Geometry of VLs

Figure 25-2  Stepwise approach to video laryngoscopy using interchangeable blades for conventional direct laryngoscopy, indirect video laryngoscopy, and obligate indirect video laryngoscopy.
Three column model

Three columns:
- Posterior
- Middle
- Anterior
<table>
<thead>
<tr>
<th>Column</th>
<th>Pathology</th>
<th>Assessment</th>
<th>Device</th>
</tr>
</thead>
<tbody>
<tr>
<td>Posterior</td>
<td>Rheumatoid arthritis</td>
<td>Range of movement of occipito-atlanto-axial complex</td>
<td>McCoy</td>
</tr>
<tr>
<td></td>
<td>Ankylosis</td>
<td></td>
<td>LMA + FOB + Aintree</td>
</tr>
<tr>
<td></td>
<td>In-line stabilisation</td>
<td></td>
<td>ILMA</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Standard blade videolaryngoscopy</td>
</tr>
<tr>
<td>Middle</td>
<td>Foreign body</td>
<td>History and examination</td>
<td>Macintosh</td>
</tr>
<tr>
<td>(air</td>
<td>Epiglottitis</td>
<td>CT/MRI</td>
<td>Standard blade videolaryngoscopy</td>
</tr>
<tr>
<td>passage)</td>
<td>Tumour</td>
<td>Nasopharyngoscopy</td>
<td>LMA + FOB + Aintree</td>
</tr>
<tr>
<td></td>
<td>Lingual tonsil</td>
<td></td>
<td>NOT ILMA (fixed curve)</td>
</tr>
<tr>
<td>Anterior</td>
<td>Decreased volume</td>
<td>Thyromental distance</td>
<td>Straight blade</td>
</tr>
<tr>
<td></td>
<td>• micrognathia</td>
<td>TMJ-TMJ distance</td>
<td>• narrow, better displacement of tissues</td>
</tr>
<tr>
<td></td>
<td>• Decreased compliance</td>
<td>TMJ-incisor distance</td>
<td>• lifts epiglottis (which is harder to deploy via hyoepiglottic ligament in cases of decreased compliance)</td>
</tr>
<tr>
<td></td>
<td>• infection</td>
<td>Overbite</td>
<td>LMA + FOB + Aintree</td>
</tr>
<tr>
<td></td>
<td>• haemorrhage</td>
<td>Mallampati score</td>
<td>Standard blade videolaryngoscopy</td>
</tr>
<tr>
<td></td>
<td>• radiotherapy</td>
<td></td>
<td>NOT McCoy (hard to deploy hyoepiglottic ligament)</td>
</tr>
<tr>
<td></td>
<td>Buck teeth (relative micrognathia)</td>
<td></td>
<td>NOT ILMA (has a fixed curve)</td>
</tr>
<tr>
<td></td>
<td>Large tongue</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Three column model

• Angulated blade VLs are useful in case

• Anterior column pathology
  ▪ The primary curve cannot be modified by compression or displacement

• Posterior column pathology
  • The primary and secondary curve is unfavorably by position
Advancing the ETT in to trachea

The Complexities of Tracheal Intubation With Direct Laryngoscopy and Alternative Intubation Devices
Levitan, Richard M. et al.
Annals of Emergency Medicine, Volume 57, Issue 3, 240 - 247
Loss of airway/difficult intubation

• Sugammadex: adjunct to the difficult airway algorithm

• Binds rocuronium or vecuronium, eliminating the paralysis induced by those agents

• Used in the clinical event of inability to intubate, its usefulness for ‘can’t intubate can’t ventilate’
Loss of airway/difficult intubation

• **QUESTION** due to the time it takes to draw up, administer, circulate and have an effect

• Considering that after 5 min of apnea the brain begins to deteriorate, the scenario of several intubation attempts followed by obtaining sugammadex, delivery and subsequent effect may not be able to salvage a patient
Recommendations for Extubation

• Awake extubation VS extubation before the return of consciousness

• General clinical factors that may produce an adverse impact on ventilation after the patient has been extubated

• **AIRWAY MANAGEMENT PLAN**: not able to maintain adequate ventilation after extubation

• Short-term use of a device that can serve as a guide for expedited reintubation

The RNSH Emergency Intubation Checklist  V2.2 Jan 17

Team
- In hours, senior Dr aware
- Out of hours, if difficulty anticipated, Anaesthesia contacted
- Team introduced:
  - Intubator 1
  - Intubator 2
  - Airway assistant
  - Drugs/monitor
  - Runner
- Problems anticipated?
- What are Plans A,B,C,D?

Patient
- ECG, BP, Sats
- ? C-spine instability
- Position optimal
- Pre-oxygenation optimal
  - Apnoeic nasal O2
- Haemodynamics optimised
  - Fluid bolus
  - Pressor

Drugs
- Fluid runs easily
- RSI drugs drawn up, doses chosen
- Rescue drugs
  - Metaraminol
  - Sugammadex
- Post intubation sedation plan
- Drug C/I or allergies?

Equipment
- Suction working
- Bag and mask with ETCO2 connected
- Guedel/nasal airways
- Laryngoscopes:
  - 2 working
- Magill's forceps
- Tubes chosen, cuff tested
- Bougie/stylet
- Tube tie or tapes
- Supraglottic airway
- Difficult airway trolley at hand?

Developed by T Fogg, D Boers, J Kennedy, J Vassiliadis and J Gatward. RNSH ED/ICU

This checklist is not intended to be comprehensive. Modifications to fit local practice are encouraged
THE VORTEX

FOR EACH LIFELINE CONSIDER:

- MANIPULATIONS:
  - HEAD & NECK
  - LARYNX
  - DEVICE

- ADJUNCTS

- SIZE / TYPE

- SUCTION / O₂ FLOW

- MUSCLE TONE

MAXIMUM THREE ATTEMPTS AT EACH LIFELINE (UNLESS GAMECHANGER)
AT LEAST ONE ATTEMPT SHOULD BE BY MOST EXPERIENCED CLINICIAN
CICO STATUS ESCALATES WITH UNSUCCESSFUL BEST EFFORT AT ANY LIFELINE

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VortexApproach.org
# Vortex Optimisation Strategies

<table>
<thead>
<tr>
<th>Head &amp; Neck</th>
<th>Sniffing Position/Jaw Thrust/Bed Height</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dentures In</td>
<td>Dentures Out</td>
</tr>
<tr>
<td>Larynx</td>
<td>Laryngeal Manipulation (Incl. Ease Cricoid)</td>
</tr>
<tr>
<td>Device</td>
<td></td>
</tr>
<tr>
<td>2 Hands Cuff Inflation Thumb Grip</td>
<td>Twist Cuff Inflation</td>
</tr>
<tr>
<td>OPA NPA</td>
<td>Fingers Introducer/Laryngoscope Bougie</td>
</tr>
<tr>
<td>FM</td>
<td>SGA</td>
</tr>
<tr>
<td>Consider Adequacy Anaesthesia/M. Relaxation</td>
<td></td>
</tr>
</tbody>
</table>

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The Emergency Airway Cognitive Tool

A. Intubation
   1st look direct C-Mac
   Stylet/bougie

B. SAD
   2nd generation
   Supraglottic Airway Device

C. Face Mask
   2 person technique
   Oral +/- Nasal airway

D. Can’t Intubate, Can’t Oxygenate
   Needle or Surgical Cricothyroidotomy

MANIPULATIONS:
- Head & Neck
- Larynx
- Device

ADJUNCTS
- Size / Type
- Suction / O₂ Flow
- Muscle Tone

Adapted from Difficult Airway Society guidelines 2015 and the Vortex approach © Nicholas Chrimes 2013, 2016 (used with permission)
Cardiovascular complications

Arrhythmia

Perioperative MI
Major adverse cardiovascular events

• Major adverse cardiovascular events (MACE) : 15% of lawsuits against surgeons and anesthesiologists
  ▪ 64% : death
  ▪ 21% : brain damage

• Emergency surgery, total joint replacement, nighttime and weekend surgeries : **HIGHER** perioperative morbidity and mortality as well

Major adverse cardiovascular events

• Patient-related risks for MACE in the perioperative period
  ▪ Pre-existing ischemic coronary disease
  ▪ Systolic and diastolic heart failure
  ▪ Male gender
  ▪ Diabetes
  ▪ Renal insufficiency
  ▪ Age greater than 65 years

Cardiovascular complications after non-cardiac surgery

• Cardiac complications: common after major non-cardiac surgery

• 30%: major surgery in the context of at least one cardiovascular risk factor

• The 30-day mortality rate: 0.5–2%

• Largest cause of death: major adverse cardiac events (MACE) → mostly myocardial infarction (MI)
Cardiovascular complications after non-cardiac surgery

- The spectrum of myocardial damage → injury → ischaemia → infarction
  
  - Asymptomatic troponin rise: strongly associated with mortality
  - Myocardial injury after non-cardiac surgery (MINS): widely recognized

- New postoperative arrhythmias, with paroxysmal atrial fibrillation (AF) : 3%
  
  - Many resolve spontaneously
  - Paroxysmal AF persists stroke is 1.5%, vs. 0.3% for those in sinus rhythm
Scenario

- A 68-year-old man develops sudden-onset fast atrial fibrillation during an emergency laparotomy under general anesthesia for an ischemic small bowel. The patient is hypotensive, with an irregular narrow complex tachycardia and a ventricular rate of 140 beats per minute. Cardiovascular stability is restored with an intravenous fluid bolus, vasopressors, electrolyte replacement, and an amiodarone infusion. Postoperatively the patient is transferred to the intensive care unit where he develops sudden-onset ventricular tachycardia necessitating immediate electrical cardioversion. The patient has further amiodarone loading and further electrolyte optimization.
Arrhythmia

• Some form of arrhythmia: not an uncommon finding

• Narrow and broad complex tachy- and bradyarrhythmias: most often attributable to pre-existing disease

• Outside cardiac and thoracic surgery, the incidence of postoperative atrial fibrillation: 3–10%
Arrhythmia

• Precipitating factors: **NOT** always clear
  - Catecholamine stress caused by tissue trauma and pain
  - Hypovolaemia
  - Atrial stretch
  - Hypoxia (causing pulmonary vasoconstriction)
  - Electrolyte disturbances
Arrhythmia

• Haemodynamic effects: subtle
  • Loss of atrial ‘kick’ reduces stroke volume by 25%

• Tachycardia: myocardial ischaemia through loss of diastolic filling time and increased myocardial work
  • Chemical or electrical cardioversion to restore sinus rhythm
Arrhythmia

• Patients
  • Not have haemodynamic instability
  • Fail cardioversion
  • Low left ventricular ejection fraction

• Unlikely to sustain sinus rhythm: rate controlled
  • Beta-blockers, calcium channel antagonists and digoxin
Arrhythmia

• Patients who experience AF: twice stroke within one year postoperatively

• UK National Institute of Health and Care Excellence (NICE): postoperative AF: treated in the same way as AF from any other cause

• Stroke $\rightarrow$ CHADS$_2$-VASC

• Anticoagulation $\rightarrow\geq 2$
<table>
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<tr>
<th>Risk factor</th>
<th>Scoring</th>
<th>Annual stroke risk</th>
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<tbody>
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<td>+1</td>
<td>0 points: 1.9%</td>
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<tr>
<td></td>
<td></td>
<td>1 point: 2.8%</td>
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<tr>
<td></td>
<td></td>
<td>2 points: 4.0%</td>
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<td></td>
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<td>3 points: 5.9%</td>
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<td></td>
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<td>4 points: 8.5%</td>
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<tr>
<td></td>
<td></td>
<td>5 points: 12.5%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6 points: 18.2%</td>
</tr>
<tr>
<td>Age ≥ 75 yrs</td>
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<tr>
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<tr>
<td>Congestive heart failure</td>
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<tr>
<td>Hypertension</td>
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<tr>
<td>TIA/stroke</td>
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<td></td>
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<tr>
<td>Vascular disease</td>
<td>+1</td>
<td></td>
</tr>
<tr>
<td>Diabetes</td>
<td>+1</td>
<td></td>
</tr>
</tbody>
</table>

Scenario

• A 62-year-old man is scheduled for cystectomy. He has a history of coronary artery disease (CAD) and underwent coronary artery bypass grafting 8 years ago. He has diabetes mellitus, hypertension, and hyperlipidemia. He takes aspirin, atenolol, pravastatin, and losartan. He is able to walk up a flight of stairs without symptoms. His intraoperative course is uneventful except for tachycardia during extubation. In recovery, he is tachycardic to 110 beats per minute but denies chest pain. Troponin levels are ordered and are elevated.
Myocardial insult, ischaemia and infarction

• The definition of myocardial ischaemia: difficult in the peri-operative context

• The Joint Task Force formed by the ESC, ACC and World Heart Federation
  ▪ Requires a troponin rise above the 99th percentile
  ▪ Accompanied by chest pain
  ▪ New ST segment changes or left bundle branch block
  ▪ Ventricular wall motion abnormalities
  ▪ Intracoronary thrombus on angiography
Myocardial insult, ischaemia and infarction

• Unsuitable for peri-operative use
  ▪ Postoperative analgesia rarely experience chest pain
  ▪ Pathognomonic ECG changes: rare
  ▪ Echocardiography: not routinely performed

• The use of postoperative troponin screening:
  evolved quickly as increasingly sensitive assays become available
Myocardial insult, ischaemia and infarction

• Martinez et al.
  ▪ Sensitivity troponin-I as a screening tool for postoperative MI
  ▪ Required ECG changes or clinical symptoms
  ▪ 98% sensitivity for detection of MI

• The newest troponin assays: extremely sensitive
  ▪ Hypertension
  ▪ Heart failure
  ▪ Chronic kidney disease
  ▪ Sepsis
  ▪ Pulmonary embolism
  ▪ Transiently raised in other conditions that cause stress to the limits of physiological reserve

Spectrum of myocardial injury and troponin rise after non-cardiac surgery. MI, myocardial infarction.
Prevention of myocardial injury after non-cardiac surgery

• Oxygen supply/demand mismatch in the coronary arteries

• Coronary blood flow $\rightarrow$ principally determined by the coronary perfusion pressure

• Peri-operative hypotension $\rightarrow$ increase the risk of myocardial ischaemia
Prevention of myocardial injury after non-cardiac surgery

Cleveland Clinic, Walsh et al.:

- Correlation between lowest mean arterial pressure (MAP) and incidence of MINS
- MAP < 55 mmHg significantly increased the relative risk of MINS
  - 1.5 for 1–20 min
  - 2.0 for > 20 min
- The 30-day mortality increased if MAP was less than 55 mmHg for > 20 min

Prevention of myocardial injury after non-cardiac surgery

Selmasi et al.

- Retrospective cohort analysis: Cleveland Clinic
- Risk of MINS increased exponentially below a MAP threshold of 65 mmHg
- MINS increased with increasing durations of MAP < 65 mmHg from 1 to 90 min

Prevention of myocardial injury after non-cardiac surgery

• Difficult to make definitive clinical practice recommendations based on these studies: TIGHTER BLOOD PRESSURE MANAGEMENT: reduce the risk of MINS in the peri-operative period

• Maintaining physiological homoeostasis
  ▪ Preventing hypoxia
  ▪ Avoiding hyperglycaemia
  ▪ Ensuring normovolaemia

Postoperative surveillance and treatment of myocardial injury after non-cardiac surgery

• CCS guideline: measure troponin daily for 2–3 days postoperatively

• Refer to an internal medicine: diagnosis of MINS

• Peri-operative MI rate of 3–6%
  ▪ 55% : supply/demand mismatch
  ▪ 27% : thrombus
  ▪ 8% : non-obstructive in nature

Prognosis for myocardial injury after non-cardiac surgery

• The risk of cardiac death at one year: 3 to 11% in patients with MINS

• Compared with a baseline risk of 3% in postoperative patients: normal troponin levels

• Specific treatment for MINS → area of active research
Hospital Risk Management
เหตุการณ์ซึ่งมีโอกาสจะก่อให้เกิดความคลาดเคลื่อน หรือเกิดภายในหน่วยงาน แต่ไม่มีความเสียหายใด

เกิดความคลาดเคลื่อนซึ่งระหว่างหน่วยงาน ซึ่งไม่ถึงผู้ป่วย/โรงพยาบาล/เจ้าหน้าที่ แต่ยังไม่มีความเสียหายใด

เกิดความคลาดเคลื่อนกับผู้ป่วย/โรงพยาบาล/เจ้าหน้าที่ แต่ไม่ได้รับอันตราย/เสื่อมเสียชื่อเสียง/ทรัพย์สินเสียหายเล็กน้อย มูลค่าไม่เกิน 5,000 บาท

เกิดความคลาดเคลื่อนกับผู้ป่วย/โรงพยาบาล/เจ้าหน้าที่ ซึ่งต้องเฝ้าระวัง/ติดตามเพิ่มเติม ซึ่งเสื่อมภาพพจน์เสียหาย เกิดความไม่ไว้วางใจจากผู้ป่วยและความไม่สะดวกขับขันระหว่างบริการ ทรัพย์สินเสียหายเล็กน้อย มูลค่ามากกว่า 5,000 บาทแต่ไม่เกิน 10,000 บาท
• เกิดความคลาดเคลื่อนกับผู้ป่วย/โรงพยาบาล/เจ้าหน้าที่ ส่งผลให้เกิดอันตรายชั่วคราวและต้องมีการบริบัติรักษา เกิดความไม่ไว้วางใจจากหน่วยงานของรัฐ/หน่วยงานเอกชน /ทรัพย์สินเสียหายมีมูลค่ามากกว่า 10,000 บาท แต่ไม่เกิน 50,000 บาท

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เกิดความคลาดเคลื่อนกับผู้ป่วย/โรงพยาบาล/เจ้าหน้าที่ ส่งผลให้เกิดอันตรายทางทรัพย์สินเสียหาย มีมูลค่าตั้งแต่ 100,000 บาท แต่ไม่เกิน 200,000 บาท ชื่อเสียงภาพพจน์เสียหาย ปรากฏในสื่อสาธารณะ

เกิดความคลาดเคลื่อนกับผู้ป่วย/โรงพยาบาล/เจ้าหน้าที่ ส่งผลให้ต้องทำการช่วยชีวิต การบาดเจ็บ/เจ็บป่วยจากงานในระดับรุนแรง/ทรัพย์สินเสียหายมีมูลค่าตั้งแต่ 200,000 บาทแต่ไม่เกิน 500,000 บาท ชื่อเสียงภาพพจน์เสียหาย ปรากฏในสื่อสาธารณะ

เกิดความคลาดเคลื่อนกับผู้ป่วย/โรงพยาบาล/เจ้าหน้าที่ ซึ่งอาจเป็นสาเหตุของการเสียชีวิต/ทรัพย์สินเสียหาย มีมูลค่ามากกว่า 500,000 บาท ชื่อเสียงภาพพจน์เสียหาย ปรากฏในสื่อสาธารณะ/ถูกฟ้องร้องต่อองค์กรวิชาชีพและฟ้องร้องทางกฎหมาย
The impact of a complication on health

• For a patient, suffering an adverse event or complication: increased pain, prolonged hospital stay or temporary/permanent disability

• Complication: indirectly or directly to their death

• Physical harms of adverse events
  ▪ Psychological morbidity, including post-traumatic stress disorder
  ▪ Loss of trust in an individual healthcare provider or institution
Human factors in preventing complications in anaesthesia

- Human factors are key to the safe delivery of healthcare in the UK

  “enhancing clinical performance through an understanding of the effects of teamwork, tasks, equipment, workspace, culture and organisation on human behaviour and abilities and application of that knowledge in clinical settings”

  “the science of improving human performance and well-being, by examining all the effectors of human performance”

Moneypenny MJ. When are ‘human factors’ not ‘human factors’ in can't intubate can't oxygenate scenarios? When they are ‘human’ factors. British Journal of Anaesthesia 2017; 118: 469–9
<table>
<thead>
<tr>
<th>Factor</th>
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<tr>
<td>Having experience</td>
<td>1194</td>
<td>59.8</td>
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<tr>
<td>Experienced assistant</td>
<td>681</td>
<td>34.1</td>
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<tr>
<td>Vigilance</td>
<td>1198</td>
<td>60.0</td>
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<tr>
<td>Adequate personnel</td>
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<td>Good supervision</td>
<td>152</td>
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<td>Effective communication</td>
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<td>8.3</td>
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<tr>
<td>Training</td>
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<td>3.3</td>
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<tr>
<td>Adequate equipment</td>
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<tr>
<td>Equipment maintenance</td>
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<td>5.4</td>
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<tr>
<td>Equipment check up</td>
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<td>6.1</td>
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<td>Adequate monitoring equipment</td>
<td>187</td>
<td>9.4</td>
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<tr>
<td>Comply to guidelines</td>
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<td>9.4</td>
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</table>

Data are expressed as number (%)
Table 8. Suggested corrective strategies (n = 1996)

<table>
<thead>
<tr>
<th>Strategy</th>
<th>n</th>
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<tbody>
<tr>
<td>Clinical practice guidelines</td>
<td>678</td>
<td>(34.0)</td>
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<td>Additional training</td>
<td>447</td>
<td>(22.4)</td>
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<tr>
<td>More manpower</td>
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<td>(8.1)</td>
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<td>Improvement of supervision</td>
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<td>(30.0)</td>
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<tr>
<td>Improvement of communication</td>
<td>160</td>
<td>(8.0)</td>
</tr>
<tr>
<td>More equipment</td>
<td>138</td>
<td>(7.0)</td>
</tr>
<tr>
<td>Equipment maintenance</td>
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<td>(5.5)</td>
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<tr>
<td>Quality assurance activity</td>
<td>727</td>
<td>(36.4)</td>
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<tr>
<td>Good referral system</td>
<td>45</td>
<td>(2.3)</td>
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Conclusion

• Any event affecting a patient that is undesirable, unintended, and a direct result of an anaesthetic procedure

• Not have occurred had things progressed as well as reasonably hoped

**ANAESTHETIC COMPLICATION**

• Addressed in a timely fashion, appropriate explanation and information, including provision of ongoing support for the affected person.

• Poor handling of complications can lead to complaints and litigation
Take home messages

• Desaturation
  • Administer high flow oxygen
  • Consider ‘A B C D E’

• Difficult airway
  • Calm down
  • Call for help

• Arrhythmia
  • Find cause and precipitating factor
  • Supportive and specific treatment

• Myocardial infarction
  • Detection
  • Maintaining physiological homoeostasis