1. Definitions
2. Differences between adults and children
3. Conduct of anaesthesia
   - Pre-operative period: Weight of child
     Premedication
     NPO times
     Preparation of the theatre
   - Intra-operative period: Induction
     Intubation
     Maintenance
     Monitoring
     Temperature management
     Fluid management
     Pain management
   - Post-operative management
4. Specific problems
   - Upper respiratory tract infections
   - Prematurity
Definitions

- Neonate = first 30 days of life
- Infant = first year of life
- Child = 1-12 years of age
How the child differs from the adult

<table>
<thead>
<tr>
<th>Physiological difference</th>
<th>Implication</th>
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<tbody>
<tr>
<td>1. Heart rate dependent cardiac output</td>
<td>Beware bradycardia → ↓ Cardiac output</td>
</tr>
<tr>
<td>2. Faster heart rate</td>
<td>↓ Reserve</td>
</tr>
<tr>
<td>3. Lower blood pressure</td>
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<tr>
<td>4. Faster respiratory rate, same $V_T$, thus $\uparrow V_M$</td>
<td>Tire easily, fast onset of inhalational anaesthesia</td>
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<td>5. Lower lung compliance</td>
<td>Beware barotrauma</td>
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<tr>
<td>6. Greater chest wall compliance</td>
<td>Chest wall collapses with inspiration → ↓ RV</td>
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<tr>
<td>7. Lower FRC</td>
<td>Desaturates faster, even after pre-oxygenation</td>
</tr>
<tr>
<td>8. $\uparrow$ Ratio body surface area: Body weight</td>
<td>Loose heat faster</td>
</tr>
<tr>
<td>9. Parasympathetic system dominant</td>
<td>$\blacklozenge$ Prone to bradycardia (if ↓$O_2$, drug OD, reflexes)</td>
</tr>
<tr>
<td>10. Hypoxic + hypercapnic ventilatory drive ↓</td>
<td>Depresses ventilation</td>
</tr>
<tr>
<td>11. $VO_2 = 6$ ml/kg (adult = 3ml/kg)</td>
<td>Desaturates faster, even after pre-oxygenation</td>
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<tr>
<td>12. &gt; water content (70-75% vs 50-60% in adult)</td>
<td>Dehydrates faster after vomiting or diarrhoea</td>
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<tr>
<td>Anatomical difference</td>
<td>Implication</td>
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<td>----------------------------------------------</td>
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<tr>
<td>1. Noncompliant left ventricle</td>
<td>Beware fluid overload (→ CCF)</td>
</tr>
<tr>
<td>2. Residual foetal circulation</td>
<td>Paradoxical air embolism</td>
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<tr>
<td>3. Difficult venous and arterial cannulation</td>
<td></td>
</tr>
<tr>
<td>4. Large head and tongue</td>
<td>Difficult intubation, needs pillow under shoulders to obtain adequate line of vision</td>
</tr>
<tr>
<td>5. Narrow nasal passages</td>
<td>Obstructs easily if mucus in passages</td>
</tr>
<tr>
<td>6. Anterior and cephalic larynx</td>
<td>Difficult intubation</td>
</tr>
<tr>
<td>7. Long epiglottis</td>
<td>Need straight (Magill) blade to lift epiglottis</td>
</tr>
</tbody>
</table>
| 8. Narrowest part of airway at cricoid (< 5yr) (adult = vocal cords) | - Use endotracheal tube without a cuff  
- Must have air leak @ 25cmH₂O |
| 9. Short trachea                             | Tube easily slides too deep or out of airway                                |
| 10. Short neck                               | Difficult intubation                                                        |
| 11. Prominent adenoids and tonsils           | Easily obstructs, difficult intubation                                       |
| 12. Weak intercostal and diaphragmatic muscles | Tires easily, we don’t allow spontaneous breathing for long periods         |
| 13. Small airways → high resistance to airflow | - ↑ work of breathing  
- obstructs with even small amount of mucus in airway                     |
<p>| 14. Horizontal ribs                          | Unable to increase ant-post distance of chest, thus if diaphragm is splinted (surgeon’s arm etc) → ↓ air entry |</p>
<table>
<thead>
<tr>
<th>Pharmacological differences</th>
<th>Implication</th>
</tr>
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<tbody>
<tr>
<td>1. Immature hepatic biotransformation</td>
<td>↓ Production of pCE (suxamethonium → ↑ duration of action)</td>
</tr>
<tr>
<td>2. Decreased protein binding</td>
<td>↑ free (active) fraction of drugs</td>
</tr>
<tr>
<td>3. Rapid rise in $F_A/F_I$ (due to ↑ $V_m$)</td>
<td>Rapid induction and recovery (inhalational agents)</td>
</tr>
<tr>
<td>4. ↑ MAC</td>
<td>Need &gt; MAC</td>
</tr>
<tr>
<td>5. &gt; Volume of distribution (H$_2$O soluble drugs)</td>
<td>&gt; dose muscle relaxants needed</td>
</tr>
<tr>
<td>6. Immature neuromuscular junction</td>
<td>• ↑ sensitivity to nondepolarising muscle relaxants</td>
</tr>
<tr>
<td></td>
<td>• Resistance to suxamethonium</td>
</tr>
<tr>
<td>7. ↑ sensitivity of respiratory centre for opiates, opiates ↑ crossing of the immature BBB. ↓ Metabolism of opiates (immature liver)</td>
<td>↑ Sensitivity for opiates (Respiratory depression)</td>
</tr>
<tr>
<td>Other differences</td>
<td>Implication</td>
</tr>
<tr>
<td>--------------------------------------------------------</td>
<td>------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>1. Nonshiver thermogenesis by metabolism of brown fat</td>
<td>▪ Volatiles ↓ brown fat metabolism  &lt;br&gt;▪ Can’t shiver, thus easily gets hypothermic</td>
</tr>
<tr>
<td>2. Immature renal function &lt; 6 months</td>
<td>↓ excretion of drugs → ↑ t½, ↓ Na⁺ retention → ↓ Na⁺</td>
</tr>
<tr>
<td>3. 75% HbF at birth</td>
<td>≠ bind 2,3-DPG → O₂Hb dissociation curve shifts to left → ↑ affinity of Hb for O₂ → ↓ offloading of O₂ to tissues</td>
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Conduct of anaesthesia

1. Pre-operatively:
   • weigh child or estimate:
   • Nil per os:

   Weight = (age x 2) + 9

<table>
<thead>
<tr>
<th>Clear fluids</th>
<th>Breast milk</th>
<th>Solids or formula</th>
</tr>
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<tbody>
<tr>
<td>2 hours</td>
<td>4 hours</td>
<td>6 hours</td>
</tr>
</tbody>
</table>

   • Premedication:
     1. Midazolam 0.3 mg/kg po
     2. Tilidine drops 1mg/kg (2.5 mg/drop)
• Preparation of theatre:

1. Laryngoscopes (different sizes, straight and curved blades)

2. Endotracheal tube – Size = age/4 +4

3. Jackson-Reese breathing circuit

4. Theatre temperature 23-28°C, Bair® hugger, overhead heater

5. Emergency drugs (atropine – prone to bradycardia)
   (suxamethonium – prone to laryngospasm)

6. Prepare drip: 200 ml R/L – add 10ml 50% dextrose (=2.5%)
   Fluid rate regulator (IVAC, dial-a-flow etc)
   60 dropper giving set
2. Intra-operatively

a). Induction: Adults: IV induction
   Children don’t tolerate drips →**inhalational induction** → Halothane → Sevoflurane

   <20 kg: Jackson-Reese breathing system
   No valves → ↓ work of breathing
   Light weight → doesn’t pull on child
   ↓ dead space

   **BUT:** you need high fresh gas flows (2.5 x \( V_m \)) to prevent rebreathing of \( \text{CO}_2 \)

If child needs **rapid sequence induction** (risk of aspiration) we insert the drip when he/she is still awake. We can use EMLA (eutectic mixture of local anaesthetics) to numb the skin. We ALWAYS give atropine prior to suxamethonium in children (to prevent bradycardia)

If the child is **very uncooperative**, we can give an IM or p.o. sedation dose of Ketamine (5mg/kg) and do the inhalational induction or insert the IV line when the child has calmed down.

We allow a parent to accompany the child to theatre. It calms them down.
b). Intubation:

Adults: mostly after muscle relaxant
Children: can be intubated without relaxant

Can use one of 2 devices:
- Endotracheal tube (ETT) if risk of aspiration or very small baby
- Laryngeal mask (LM) if no risk of aspiration + short procedure, thus spontaneous breathing allowed

ETT: 1. No cuff if <10 years of age
2. **Size = age/4 + 4** (also keep ½ size smaller ETT ready)
3. **Depth = age/2 +12** (cm)
4. Must have air leak past ETT at 25cmH$_2$O
c). Maintenance:

Mainly vapour @ 1 MAC with 50% O₂ (FiO₂ = 0.5) and 50% air or N₂O

Can use TIVA (total IV anaesthesia) if malignant hyperthermia risk. Then induction and maintenance with Propofol (avoid vapours).
d). Monitoring

1. Basic monitors: ECG, NIBP, O₂ saturation

2. Temperature, capnography
e). Temperature management:

- Bair® hugger
- Warm fluids
- Cover child (with orthopaedic wool)
- Theatre temperature 25-28°C
- Overhead heater
f). Fluid management:

1. Maintenance: (give R/L)

   4:2:1 rule:  
   - 1<sup>st</sup> 10 kg = 4ml/kg
   - 2<sup>nd</sup> 10 kg = 2ml/kg
   - thereafter = 1ml/kg

2. Starvation period: Maintenance (4:2:1 rule) x hours starved (give R/L)

3. Third space losses: minor surgery = 1-2ml/kg/h (give R/L)
   major surgery = 15 ml/kg/h (give R/L)

4. Acute losses:
   - < 10% blood loss - replace with crystalloids (3:1) or colloids (1:1)
   - > 10% blood loss - replace with packed cells (choose a formula):

   \[ 1.5 \times \text{kg} \times (\text{Hct}_2 - \text{Hct}_1) \]
   or

   \[ \frac{\text{EBV} \times (\text{Hct}_2 - \text{Hct}_1)}{\Delta \text{Hct}} \]

   (EBV = wt x blood volume) and Blood volume: neonate = 90ml/kg
   toddler = 80ml/kg
   adult male = 75ml/kg
   adult female = 65ml/kg

S = Starved
T = Third space losses
A = Acute losses
R = Regular maintenance fluid
T = Total
Example of fluid management:

30 kg child, starved for 6 hours for minor surgery with minimal blood loss

1. Maintenance:
   - 4x10 = 40 ml
   - 2x10 = 20 ml
   - 1x10 = 10 ml
   - 70 ml/h

2. Starvation: 70 ml/h x 6 hours = 420 ml → give over 2 hours

3. Third space losses: 1ml/kg/h = 30 ml/h

g). Pain management

Local blocks

Paracetamol

NSAID’s

Opioids – Tilidine (Valaron) drops
3. Post-operatively

Extubate children wide awake

No pain allowed
Specific Problems:
1. Upper respiratory tract infection (URTI)

→ Problem:
- Prone to laryngospasm/bronchospasm
- ETT blocks due to secretions
- Vapours suppress immune response → worsening of infection
- Fever → ↑ VO₂

→ Management:
a). Light URTI - < 1 year old → cancel
   > 1 year old → weigh benefits vs risks

b). Severe URTI - common cold → cancel x 2/52
   - fever, cough, entire airway → cancel x 6/52
2. Prematurity

Problems:
- Post-operative apnoea
- Hypoglycaemia
- Hypothermia
- Retinopathy (associated with prematurity, ↑FiO₂, prolonged mechanical ventilation)
- Intra-cranial bleeding

Management:
- Monitor for apnoea post-operatively, no elective surgery < 50 weeks gestation
- Monitor glucose peri-operatively
- Monitor and manage temperature peri-operatively
- Avoid FiO₂ > 0.4 in neonates
- Avoid intubating baby awake/avoid severe pain → sympathetic stimulation → intra-cranial bleeding