Paediatric Anaesthesia - An Update

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Dept of Pain Medicine & Palliative Care

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Paediatric Anaesthesia
The difficulties with children…

- Small - airways, veins etc etc
- High metabolic rate
- High oxygen requirement
- Airway is crucial…
- Need good, committed assistance
- Knowledge of equipment
- Extends into the post-op period…
**Rehash**

- Fasting
- Premeds
- Laryngospasm
- No venous access
- Blood loss
- Syndromes

**New stuff**

- Obesity
- Cuffed ETT in kids / circuits / new machines
- Difficult airway / LMAs
- Emergence delirium
- Who does paediatric anaesthesia?
- Safety / complications
FASTING

6 4 2

• 6 HOURS SOLIDS & FORMULA

• 4 HOURS BREAST MILK

• 2 HOURS CLEAR FLUIDS

• UNIFORM APPROACH

• FLEXIBILITY
PREMEDS

- Less than we use to
- Atropine rarely now
  - Can give orally 10mcg/kg
- Topical
  - EMLA
  - 4% amethocaine gel
    - faster onset
    - RCH Melbourne
  - Other
PREMEDS

• Midazolam
  – Oral 0.5mg/kg / nasal 0.3mg/kg (max 15mg)
  – Quick onset 15mins
  – Beware of ataxia

• Other - oral - more sedating / ADHD
  – Ketamine / midazolam (3mg/kg / 0.3mg/kg)
  – Clonidine 2-4 μg/kg
Anaesthesia: Induction

• Whatever is easier for you and the patient
  – Inhalation
    • Easy
    • Familiar equipment
    • Good airway control
    • Sevoflurane
    • Better conditions for IV access
  – Intravenous
    • use EMLA or amethocaine
    • more skill required
    • more rapid control gained
    • more pleasant
    • IV access established before GA
    • May be phobic re needles
Anaesthesia: Induction

Parental presence during induction
  – Has to be in the best interests of the child
  – Often done for the parent not the child
  – Depends upon layout of theatres
  – Adequate staff to escort parent out
  – ? Only in elective cases
  – Anaesthetist has final say
The Airway

Figure 1. Laryngoscope-guided tracheal intubation with the manikin floating free with the head between the knees.
Infant and Adult Larynx
Position of the Larynx in Children

Westhorpe RN. Anaes Intens Care 1987; 15:384-388
Position of the Larynx in Children

Westhorpe RN. Anaes Intens Care 1987; 15:384-388
Infant Larynx - Implications for the Anaesthetist

• Larynx may appear displaced anteriorly
• Epiglottis more likely to require physical displacement to view glottis
• Neck flexion unlikely to improve intubation angle
Straight blade vs curved blade
What is Laryngospasm?

Glottic closure caused by reflex constriction of the intrinsic and extrinsic laryngeal muscles

- Closure of vocal cords
- Closure of vocal cords plus false cords
- Closure of vocal cords, false cords and supraglottis
- Intrinsic laryngeal muscles → Intrinsic plus extrinsic laryngeal muscles
- Simple shutter → Shutter plus ball valve
Incidence of Laryngospasm

Adults 8.7/1000
Children 17.4/1000 (2x)
Young Infants 27.6/1000 (3X)


Children 9.4/1000
Age <1yr (increased risk: Odds ratio 2.33)

## Laryngospasm and URTI’s

### Risk Factors

<table>
<thead>
<tr>
<th>Risk Factor</th>
<th>OR</th>
<th>p</th>
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<tbody>
<tr>
<td>Parent: active URTI</td>
<td>1.92</td>
<td>0.01</td>
</tr>
<tr>
<td>Age &lt;1yr</td>
<td>2.33</td>
<td>0.04</td>
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<tr>
<td>Airway surgery</td>
<td>1.97</td>
<td>0.01</td>
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<tr>
<td>Less experienced staff</td>
<td>1.75</td>
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</table>

### No apparent risk

<table>
<thead>
<tr>
<th>Risk Factor</th>
<th>OR</th>
<th>p</th>
</tr>
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<tbody>
<tr>
<td>Parent: recent URTI</td>
<td>1.05</td>
<td>0.86</td>
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</table>

*Schreiner M.S. et al*

*Anaesthesiology 1996:85:475-80*
Factors increasing the risk of Laryngospasm

- **Anaesthetic factors:**
  - Atropine vs no vagolytic ns
  - Intubation vs no intubation 2x
  - NG tube 2.5x

- **Patient factors**
  - URTI 5x
  - Asthma 3x

- **Surgical/proceedure factors**
  - Airway surgery 3x
  - Oesophagoscopy/dilatation 4x
  - Appendicectomy 2x

Sequelae of Laryngospasm

- SpO2 < 85% 80/123
- HR < 80% baseline 3/123
- Muscle relaxant given 70/123

_Schreiner MS et al. Anesthesiology, 1996; 85: 475-80_

- 136,929 pts - 1232 cases of laryngospasm -
  6 cardiac arrests (5/1000): ?adults/paediatrics


- 150 episodes of cardiac arrest in 1 million+ anaesthetics: 9
due to laryngospasm

_Morray J et al, Anesthesiology, 2000_
Preventing Laryngospasm

- Avoid trouble
  - Cancel if active URTI
  - If occurs at induction, be ready for laryngospasm at emergence!
  - Topical lignocaine
Treatment of Laryngospasm

Jaw thrust / clear upper airway
100% O2
CPAP/Gentle +ve press
Remove/stop stimulus

Lignocaine 2mg/kg
Propofol 0.25-2mg/kg

Suxamethonium 0.1-.2 mg/kg
Suction

Suxamethonium 1-2 mg/kg
Intubation

Stabilise & continue planned management
Treatment of Laryngospasm: Complete airway obstruction- **NO IV!**

HELP!!
Sux administration

- **IM**
  - (1) 4mg/kg
    - Max onset: 3.3 min
  - (2) 2mg/kg
    - Apnoea: 3.5 min
  - (3) 3mg/kg
    - Max onset: 5min

- Intra-Lingual oral
  - (2) 1mg/kg
    - Apnoea: 1.25 min
    - (arrhythmias)

- Intra-Lingual Sub mental

- Intra osseous
  - (3) 3mg/kg
    - Max onset: 4.5 m
    - + massage: 2.15 m
Conventional View of Paediatric vs Adult Larynx

Eckenhoff JE. Anesthesiology 1951; 12:401-410
Comparison of sub glottic oedema in Adult and Paediatric patients

<table>
<thead>
<tr>
<th></th>
<th>Normal</th>
<th>Edema 1mm</th>
<th>Resistance</th>
<th>X-Section Area</th>
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<tbody>
<tr>
<td>Infant</td>
<td><img src="image1" alt="Infant Normal" /></td>
<td><img src="image2" alt="Infant Edema" /></td>
<td>↑ 16x</td>
<td>↓ 75%</td>
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<tr>
<td>Adult</td>
<td><img src="image3" alt="Adult Normal" /></td>
<td><img src="image4" alt="Adult Edema" /></td>
<td>↑ 3x</td>
<td>↓ 44%</td>
</tr>
</tbody>
</table>
Shortcomings of cuffed paediatric tracheal tubes
Poor venous access

- Other tricks
- Where are your options?
  - Cubital fossa
  - Anterior wrist
  - Lateral aspect of foot
  - Blind cephalic vein at wrist
  - Blind long saphenous vein
  - Intraosseous
  - Ultrasound!
Poor venous access
Intraosseous vascular access

- Up to 6 years
- Can give anything
- Upper medial aspect of tibia
  - level of tibial tuberosity
- Push firmly
- Medullary cavity via emissary vv to systemic circulation
- **Use a large flush**
Paediatric Anaesthetic Circuits

• T – piece vs Paediatric circle

• Increasing use of paediatric circle with expensive volatile agents

• Paediatric circle
  – Slower inhalational induction
  – Greater potential for leaks
  – Compliance of circle important
  – Most relevant in infants / neonates

• USE WHAT YOU ARE FAMILIAR WITH
Paediatric Anaesthetic Circuits
Old Anaesthetic Machines
New Anaesthetic Work Stations
Blood loss
Pre-operative preparation

- Know your surgery/know your surgeon
- Estimate blood volume:
  - Neonate - 100 mls/kg
  - Child - 80 ml/kg
  - Adult - 70 ml/kg
- Pre-op tests - FBC, coagulation studies
- HAVE THE BLOOD READY PRE-OP !!
Blood loss is USUALLY obvious

BUT beware of loss:

- Under the drapes
- Into drains eg chest drain
- Concealed in the wound eg pelvis
- Into soft tissues eg # femur
Replacement - What & How Much??

- Be guided by BP, HR, urine output,
- Maintain cardiac output/oxygen delivery
- If in doubt, 10ml/kg bolus and re-assess
- “Children tolerate fluid loading well”
- “Rather be 10-20% ahead than 20% behind”
WHAT TO DO IF YOU GET BEHIND IN REPLACING BLOOD LOSS

• Get help
• Tell the surgeon to stop operating or pack the wound
• Patient head down
• Extra IV drips - arms
  - external jugular vein
  - intraosseous in children (leg)
### Radiometer ABL System 625 - Patient Report

**Identification**
- Operator ID: 0553569
- Patient ID: 0553569
- Patient temp.: 37.0 °C
- FiO2: 21.0 %
- Sample type: Arterial

**Blood Gas Values**

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<th>Value</th>
<th>Unit</th>
<th>Value</th>
<th>Unit</th>
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</thead>
<tbody>
<tr>
<td>pH</td>
<td></td>
<td>pCO2</td>
<td>mmHg</td>
</tr>
<tr>
<td>pO2</td>
<td>mmHg</td>
<td></td>
<td></td>
</tr>
<tr>
<td>pCO2</td>
<td>mmHg</td>
<td></td>
<td></td>
</tr>
<tr>
<td>pO2</td>
<td>mmHg</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ca²⁺</td>
<td>mmol/L</td>
<td></td>
<td></td>
</tr>
<tr>
<td>K⁺</td>
<td>mmol/L</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Na⁺</td>
<td>mmol/L</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cl⁻</td>
<td>mmol/L</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Glu</td>
<td>mmol/L</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lac</td>
<td>mmol/L</td>
<td></td>
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**Temperature Corrected Values**

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<th>Value</th>
<th>Unit</th>
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</thead>
<tbody>
<tr>
<td>pH</td>
<td></td>
<td>pCO2</td>
<td>mmHg</td>
</tr>
<tr>
<td>pO2</td>
<td>mmHg</td>
<td></td>
<td></td>
</tr>
<tr>
<td>pCO2</td>
<td>mmHg</td>
<td></td>
<td></td>
</tr>
<tr>
<td>pO2</td>
<td>mmHg</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ca²⁺</td>
<td>mmol/L</td>
<td></td>
<td></td>
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<tr>
<td>K⁺</td>
<td>mmol/L</td>
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<tr>
<td>Na⁺</td>
<td>mmol/L</td>
<td></td>
<td></td>
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<tr>
<td>Cl⁻</td>
<td>mmol/L</td>
<td></td>
<td></td>
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<tr>
<td>Glu</td>
<td>mmol/L</td>
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<tr>
<td>Lac</td>
<td>mmol/L</td>
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**Metabolite Values**

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<tbody>
<tr>
<td>Glu</td>
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<tr>
<td>Lac</td>
<td>mmol/L</td>
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**Blood Oximetry Values**

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<tr>
<td>O₂Hb</td>
<td>g/dL</td>
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<tr>
<td>sO₂</td>
<td>%</td>
</tr>
<tr>
<td>COHb</td>
<td>%</td>
</tr>
<tr>
<td>MetHb</td>
<td>%</td>
</tr>
<tr>
<td>Rb</td>
<td>%</td>
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**Oxygen Status**

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</thead>
<tbody>
<tr>
<td>Hct</td>
<td>%</td>
</tr>
<tr>
<td>TdO₂</td>
<td>%</td>
</tr>
<tr>
<td>p50(aO₂)</td>
<td>mmHg</td>
</tr>
<tr>
<td>COHb</td>
<td>%</td>
</tr>
<tr>
<td>MetHb</td>
<td>%</td>
</tr>
<tr>
<td>Rb</td>
<td>%</td>
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**Acid Base Status**

<table>
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<th>Value</th>
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<tr>
<td>HCO₃⁻</td>
<td>mmol/L</td>
</tr>
<tr>
<td>SBC</td>
<td>mmol/L</td>
</tr>
<tr>
<td>tCO₂ (P)</td>
<td>mmol/L</td>
</tr>
<tr>
<td>MBE</td>
<td>mmol/L</td>
</tr>
<tr>
<td>SBE</td>
<td>mmol/L</td>
</tr>
<tr>
<td>Anion gap (K⁺)</td>
<td>mmol/L</td>
</tr>
</tbody>
</table>

**Printed August 19, 2002 9:10**
Replacement - What & How Much??

- Maintain patient’s Hct > 24 (Hb > 70 g/L)
- Important:
  - Warm the blood
  - Ca\(^{2+}\) supplements (0.5ml/10kg)
  - Beware K\(^{+}\) load (may need frusemide)
Syndromes

Would you have invested?

Microsoft Corporation, 1978
 Syndromes

• Know the common ones
• If in doubt, look it up
• I think about:
  – Airway – can I get the tube in?
  – MH risk?
  – Myopathy? How they handle muscle relaxants, can I use
    • Suxamethonium
    • Normal doses of nondepolarisers
Syndromes and Anaesthesia

• Down’s syn
  – Large tongue
  – C spine instability
  – Subglottic stenosis
  – Floppy, URTI’s
  – Delayed
  – Heart disease
Airway and Syndromes
Micrognathia

Myopathies

- Consider use of muscle relaxant carefully
- Suxamethonium
  - K+ release / rhabdomyolosis
  - Pronounced muscle contraction/ no relaxation
- Non – depolarisers
  - Response – often need less
  - Metabolism - ? cisatracurium
Malignant Hyperthermia

- Take a family history
- Beware of Lithgow!
- Ring Neil Street at CHW
- Specific myopathies
  - Central core disease
Worrying airway signs

• Stridor
• Altered voice or aphonia
• Right neck pathology
• Drooling
• Sitting, won’t lie down
• Copious blood
• Surgical emphysema
Airway - foreign bodies
A difficult airway - how I do it

• Another pair of hands - iv, give drugs etc
• In theatre, everything drawn up, ? ENT
• 100% O2 / sevoflurane / gentle CPAP
• Take your time
• Topical lignocaine to airway
• Plan airway
  – consider ETT size, maybe smaller than for age
  – Steroids – hydrocortisone 1mg/kg
  – Be happy with an oral ETT
Airway LA Topicalisation

• 2-3mg/kg lignocaine
ANAESTHETIC CONSIDERATIONS

Airway
Bougies

- Soft and flexible
- Facilitate intubation by guiding ETT into trachea
- Intubate trachea with bougie first, then railroad ETT over bougie and into trachea
ANAESTHETIC CONSIDERATIONS

Airway
FIG. 2. Anterior view of the adult and infant larynx, showing the smaller dimensions of the thyrohyoid and the cricothyroid ligaments in the infant.
Obesity
Paediatric Obesity & Anaesthesia

- 6171 patients
- Used pre-obesity epidemic growth charts – 1960’s

Nafiu et al.
Paed Anaesthesia
2007; 17: 426-430

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Biophysical characteristics of a pediatric surgical population</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Male, n = 3359</td>
</tr>
<tr>
<td>Age (mean year ± sd)</td>
<td>11.6 ± 5.2</td>
</tr>
<tr>
<td>Height (mean meter ± sd)</td>
<td>1.5 ± 0.3</td>
</tr>
<tr>
<td>Weight (mean kg ± sd)</td>
<td>52.8 ± 29.2</td>
</tr>
<tr>
<td>BMI (mean kg·m² ± sd)</td>
<td>21.6 ± 6.8</td>
</tr>
<tr>
<td>BMI category (%)</td>
<td></td>
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<tr>
<td>Normal weight (kg)</td>
<td>67.0</td>
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<tr>
<td>Overweight</td>
<td>14.9</td>
</tr>
<tr>
<td>Obese</td>
<td>18.2</td>
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</table>
Table 2
Frequency of QA events between normal weight, overweight and obese children

<table>
<thead>
<tr>
<th>QA Events</th>
<th>Normal weight (n = 4171) (%)</th>
<th>Overweight (n = 875) (%)</th>
<th>Obese (n = 1048) (%)</th>
<th>P values&lt;sup&gt;a&lt;/sup&gt;</th>
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<tbody>
<tr>
<td>Preoperative</td>
<td></td>
<td></td>
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<tr>
<td>Asthma</td>
<td>12.7</td>
<td>14.4</td>
<td>16.1</td>
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<td>Diabetes</td>
<td>0.53</td>
<td>0.4</td>
<td>2.6</td>
<td>0.001</td>
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<td>Hypertension</td>
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<td>4.1</td>
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<tr>
<td>Intraoperative</td>
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<tr>
<td>Difficult</td>
<td>2.2</td>
<td>3.6</td>
<td>7.4</td>
<td>0.001</td>
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<tr>
<td>mask airway</td>
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<tr>
<td>Difficult</td>
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<td>0.2</td>
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<td>Bronchospasm</td>
<td>0.4</td>
<td>0.0</td>
<td>0.5</td>
<td>0.156</td>
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<td>Dental injury</td>
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<td>0.0</td>
<td>0.1</td>
<td>0.111</td>
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<tr>
<td>Cardiac arrest</td>
<td></td>
<td>0.0</td>
<td>0.0</td>
<td>ns</td>
</tr>
<tr>
<td>PACU</td>
<td></td>
<td></td>
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<tr>
<td>Upper airway obstruction</td>
<td>0.07</td>
<td>0.3</td>
<td>1.6</td>
<td>0.001</td>
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<td>Stay ≥3 h</td>
<td>0.86</td>
<td>1.3</td>
<td>1.9</td>
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<tr>
<td>≥2 antiemetics</td>
<td>0.6</td>
<td>1.1</td>
<td>1.3</td>
<td>0.039</td>
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<tr>
<td>Vomiting</td>
<td>0.4</td>
<td>0.8</td>
<td>0.6</td>
<td>0.263</td>
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<tr>
<td>Unplanned admit</td>
<td>0.5</td>
<td>0.5</td>
<td>1.0</td>
<td>0.063</td>
</tr>
</tbody>
</table>

<sup>a</sup>P values generated with Pearson chi-square with two degrees of freedom comparing the three groups. <sup>b</sup>Obese vs normal weight: P < 0.001; overweight vs normal weight: P = 0.01 for hypertension, otherwise P > 0.05 for other parameters; overweight vs obese: P < 0.01 for diabetes, difficult mask airway, difficult laryngoscopy and upper airway obstruction, otherwise P > 0.05 for all other parameters.
PACU, Postanesthesia care unit; QA events, quality assurance events.
Emergence Delirium

• Common
• Injury to child, distressing to parents, increase nursing care, if treat may delay discharge
• Lasts up to 30 mins, self limiting, resolves spontaneously
• May be separate from pain
• Increased with:
  – Tonsils or thyroid surgery
  – Middle ear surgery
  – Eye surgery
• Exclude other causes
• Use of midazolam – conflicting studies
Aetiology of Emergence Delirium

• Patient related factors
  – Age
  – Pre-op anxiety
  – Child temperament

• Anaesthetic related factors
  – Rapid emergence
  – Intrinsic characteristics of an anaesthetic
  – Adjunct medication

• Surgery related factors
  – Post-op pain
  – Type of surgery
Emergence Delirium - DD

- **D** Drugs (inhaled volatiles, ketamine, neuroleptics, anticholinergics)
- **I** Infection
- **M** Metabolic (post op pain, hypoglycaemia, uraemia, hepatic encephalopathy, adrenal insufficiency, $\downarrow Na^+, \uparrow Ca^{2+}$)
- **T** Toxins (withdrawal syndromes – alcohol, cocaine, opiates, benzodiazepines; hallucinogens)
- **O** Oxygen (hypoxia, CO, anaemia)
- **P** Psychiatric (psychosis) & CNS disorders (dementia, parkinsonism, cerebrovascular insufficiency)
- **P** Physical ($\downarrow BP$, $\downarrow CO$, bladder & bowel distension, pain)
Emergence Delirium - Summary

• Aetiology of EA/ED still not fully established
  – Younger age, pre-op anxiety, pain important
• Newer, insoluble inhaled anaesthetics (sevo, des) have ↑ incidence. Less c propofol
• Lack of reliable assessment tool
• No clear-cut preventive strategy
• 2\textsuperscript{nd} anaesthetist if ASA 3 or more
• Transfer to a specialist children’s hospital if (and need to consider distance)
  – Neonate
  – Prem (<37 weeks) and now < 52 weeks PCA
  – History of apnoeas
  – Infants & Children with unusual and/or complex medical or surgical problems who are ASA 3 or greater
New Literature
2000 - 2007

Factors to consider:

- Change in anaesthetic agents eg halothane to sevoflurane
- Improved monitoring
- Some studies look at all complications including ‘minor’ ones eg vomiting, itch etc
- Many studies come from paediatric hospitals so may not reflect what happens in ‘normal’ hospitals
- No further studies of no. of cases and outcome after Auroy’s letter in 1997 (study done in 1993)

- 297 critical incidents (2.97%)
- 80.1 % in ASA 1 or 2, 73% elective
- If < 1 year, 4x as common
- Most incidents during maintenance of anaesthesia 80%
- Respiratory events common 77% with laryngospasm alone being 35.7%
- Incidence of pharmacological / equipment problems low
- NO anaesthetic mortality

- 92,881 anaesthetics < 18yo
- PCA in non-cardiac surgery 2.9/10,000
- PCA in cardiac surgery 127/10,000
- 90% of PCA in children occur in children with
  - Congenital heart disease
  - Neonates
  - Having cardiac surgery
- POCA registry 2000
  - figures include surgical reasons eg hypovolaemia
  - Commonest anaesthetic cause was halothane

- 1996-2004 = 15,253 anaesthetics
- 35 arrests (22.9 / 10,000) 15 deaths (9.8:10,000)
- 7 arrests due to anaesthesia (4.58:10,000)
- Due to: respiratory (71.5%) and medication events (28.5%)
- Major risk factors:
  - < 1 year, ASA 3, emergency
Paediatric Anesthesia 2004; 14: 158-166
Murat I et al, Paris

- 24,165 anaesthetics over 30 months in a paediatric teaching hospital – no cardiac / neuro
- 1 death – bleed from PDA ligation in a preterm infant
- 724 adverse events intraop and 1105 in PACU
- 53% of intraop events were respiratory, 12.5% cardiac
- More common in ENT, tracheal intubation, ASA 3-5.
- Prospective reporting, anaesthetists may not have reported ‘minor’ desaturation
- NO anaesthesia related deaths

- 532 claims – 1973 – 2000 < 16 yrs
- Steady downward trend in claims for death and brain damage but these remain the dominant complications of pediatric anesthesia
- Cardiovascular (26%) and respiratory (23%) were most common damaging events

Figure 1. Trends over time. Outcome, type of event, and prevention by better monitoring. Years are grouped for illustration.
ANZCA Anaesthesia Related Mortality in Australia 2000-2002

• NO anaesthetic related deaths < 1 yo (76% over 60yo)
• 66% of deaths were in emergencies
• 50% were ASA 4 or 5 BUT 20% were ASA1-2
• No specific mention of paediatric incidence of anaesthetic related mortality
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