Paediatrics

**Neonatal anaesthesia**

**Burns management**

Outline airway problems in choanal atresia, Pierre-Robin syndrome, laryngomalacia

Outline your approach to paediatric bronchoscopy

Management of anaesthesia for teenage scoliosis surgery patient

Outline the management of anaesthesia for tracheoesophageal fistula surgery

**Paediatric respiratory failure**

Common sizes and doses

**Neonatal Resuscitation**
Neonatal anaesthesia

Neonate
birth to 28d, more usefully up to 44w post conception

Anaesthesia
poorer outcomes with anaesthesia by non-experts
increasing numbers coming to theatre as they survive more commonly

Physiology

CVS
rate dependint CO
transitional circulation
caused by hypoxia, acidosis, hypercapnia, cold
treat with 100% O₂, hyperventilate
little sympathetic tone
HbF, p50 17 mmHg
higher haematocrit (depends on cord-clamping time)
blood volume 90ml/kg
inefficient myocardium due to poorly organized myofibrils
preferential blood supply of highest pO₂ to coronary, cerebral circulation

Respiratory
large head, short neck
small diameter airway
different laryngeal angle, anterior larynx
edentulous, but tooth buds can be damaged on intubation
short trachea
mouth breathing
increased MV
compliant chest wall, horizontal ribs
noncompliant lungs
prone to apnoea, sensitive to sedative drugs

Homeostasis

temperature maintenance
high SA to volume ratio
thin skin, rapid evaporative loss
little fat
no shivering, but non-shivering thermogenesis
poor vasoconstriction
thermoneutral zone
temperature requiring minimal O₂ consumption to maintain
temperature
neonate 28-32°C at term, higher for prems
maintaining temperature in anaesthesia extremely important

Fluids
increased body water
high evaporative losses
reduced renal function
low GFR, poor concentrating ability
requirements
day 1-2 40-60ml/kg/24h (more for prems up to 200ml/kg/d)
10% dextrose plus Na⁺ 2mmol/kg/d, K⁺ 2-3mmol/kg/d, Ca²⁺, Mg²⁺ as required
continue glucose intraop (or glucose component of TPN)
lowered renal threshold for glucose
risk related to Ca²⁺ administration: burns if extravasates

Diseases
HMD
lack of surfactant prior to 34w, later in IDM
increased work of breathing, ground glass x-ray
respiratory distress, cyanosis, tracheal tug, grunting
prevention
    reduce risk of prematurity, steroids prior to delivery, tocolytics
treatment
    oxygen, CPAP, intubation, ventilation: IPPV, HFJV, oscillation,
surfactant, PLV
complications
    pneumothorax, IVH, ?NEC, chronic lung disease

Oxygen toxicity
    retinopathy of prematurity
        high pO₂, vasoconstriction, neovascularization, haemorrhage, scarring,
        retinal detachment
    rare after 30w, PaO₂<80 mmHg, <4 h

Pulmonary O₂ toxicity
    free radical generation by high FiO₂, worse with IPPV, high FiO₂, aim for
    FiO₂<60%, endothelial damage

IVH
    brain lesion associated with prematurity
    neonates: fragile vessels around ventricles: haemorrhage with rise in BP, also
    periventricular leukomalacia: ischaemia (watershed area in hypotension) with
    venous haemorrhage
    high risk at the time of intubation or volume expansion
    graded by extent, detected by u/s through fontanelle
    good prognosis unless very large
    older babies: cortical lesions more common

Apnoea
    More common with prematurity
    central, obstructive or mixed
    monitoring post anaesthetic up to 45w post conceptual in term babies here
    up to 60w in some units or with ex-prems

NEC
    abdominal distension, tram tracking, acidosis

Anaesthesia
    Assessment
        routine plus prematurity, associated abnormalities, recent course (ventilation,
        glucose..)
    Transfer
        do case in neonates if sick, ?transfer to major hospital
    Induction in theatre
        temperature monitoring and maintenance

Paediatric Anaesthesia 3.F.3 James Mitchell (3 December 2009)
IV usually not too hard: little fat, some veins invariant
intubation different: view and tube manipulation
monitoring: standard plus ECG, T, SpO₂ x 2
laryngoscopy: straight or curved blade, pick up epiglottis or not
tube size, need for leak, PCV, taping technique, nasal vs oral

Maintenance
ventilation PCV 5-20 cmH₂O 20/min, 10 l/min flow
positioning: flexible, need for head support, lying on wires etc., access usually poor, improved with hand up, oximeter lead available, tubing for IV access
fluids: Albumex 4 (no evidence), continue dextrose
maintenance plus losses: e.g. open abdomen 10 ml/kg/h

Exubtation
awake

Recovery location
depends on procedure and institution

Regional
no long-term studies, morph infusion OK, paracetamol effective, little use of NSAIDs

Fasting time
clear fluids 2h breast 3h formula 4h solids 5h
Burns Management

First aid
Remove burning debris, extinguish flames, remove from area of smoke
ABCDE management
Transfer to hospital

Primary survey
ABCDE
Location and severity of burns
Rule of 9s for area burned, modified for children
Special areas
Face, mouth, airway
Eyes

Associated injuries
Inhalational injury
More likely if facial burns
Cause of injury: smoke, toxic fumes, hot steam
Smoke inhalation
May have high COHb, give supplemental oxygen
Lung injury may produce respiratory distress syndrome
Airway burn
Develop oedema due to injury
Intubate early to secure airway
Other injuries
Electrical burns, chemical burns, blast injury etc.
Circumferential burns may require escharotomy

Obtain IV access
Large bore in non-burned area
May need to be CVC or temporary intraosseous cannula
Take baseline bloods
Start hydration
Hartmann’s solution
Maintenance (4/2/1 ml/kg formula), plus
Fasting time, plus
Burn losses 2-4 ml/kg/% burn over 24 hours
half in 8 hours
If young, may require glucose
Severe burns are often given some colloid
Monitor urine output to assess hydration
≥0.75-1 ml/kg/h desired
Give IV analgesia
Titrated doses of morphine IV
Reduced dose requirement due to fluid depletion and centralized circulation
Maintain normothermia
Warm environment
Warmed fluids

Involve surgical/burns unit for on-going management

Later issues
Infection
Prophylactic antibiotics vary by institution
Silver sulfadiazine dressings
Nutrition
Commonly require NGT or IV supplementation
Particularly Zn, ω3 fatty acids

Anaesthesia
Surgery
Commonly debridement and grafting
Multiple procedures over weeks or months
Commonly start about 5 days after injury

Preoperative
Routine, plus
Careful airway assessment
Investigation
U+E to assess renal function
FBE, coagulation
Crossmatch for all debridements

Induction
Good IV access required
Commonly spontaneous ventilation with LMA
Induction with
Thiopentone or propofol commonly
Ketamine: less fall in cardiac output than other IV agents
Halothane: vasodilator, myocardial depressant, ↓ platelet function
but still commonly used

Muscle relaxation
Often not required
Increased number of post-junctional receptors
Decreased sensitivity to non-depolarizing agents
Increased K⁺ rise with suxamethonium
Unsafe from around 1 week to 12 weeks (or healed)
Lower dose useable (in theory)

Analgesia
IV narcotic
Nerve blocks for donor sites
Posterior cutaneous nerve of thigh
1/4 of the way from ischial tuberosity to greater trochanter
In gluteal fold, LOR before reaching muscle or on withdrawal
Lateral cutaneous nerve of thigh
2 cm inferior to ASIS between internal oblique and ilium
Femoral nerve
Lateral to femoral artery in the groin
2 pops on insertion of 45° bevel needle
Sciatic nerve
Intersection of biceps femoris and sciatic nerve in leg
Nerve passes from midpoint of ischial tuberosity and greater trochanter to popliteal fossa
Muscle passes from ischial tuberosity to head of fibula
Outline airway problems in choanal atresia, Pierre Robin syndrome, laryngomalacia.

Choanal atresia
- Congenital atresia of the passage from nose into pharynx
- Unilateral or bilateral
- Membranous, cartilaginous or bony

Presentation
- Often detected at birth
- Respiratory difficulty and hypoxia as neonates are obligate nose breathers
- Tested for by occlusion of each nostril or passage of cannula

Immediate management
- Oral airway
- Supplemental oxygen
- Infants are typically pink and well-oxygenated when crying but hypoxic when feeding or asleep

Pierre Robin syndrome
- Congenital anomaly of the jaw, tongue and palate
- Cause uncertain
- Micro- or retro-gnathia, glossoptosis, cleft or arched palate (lip intact)

Presentation
- Obvious deformity at birth
- Commonly respiratory obstruction when supine
- May lead to cor pulmonale if untreated

Anaesthetic problems
- Usually difficult intubation
- Difficulty usually reduced with age as mandible grows
- May require gas induction and fiberoptic intubation
- Assistant retracting tongue may be helpful

Laryngomalacia
- Infantile larynx
- Normal variant laryngeal anatomy
- Unusually soft cartilaginous structures
- Epiglottis and surrounding structures cause dynamic obstruction

Presentation
- Stridor developing soon after birth
- Absent with quiet breathing
- Increasingly noisy with distress
- Resolves over first 6 months of life

Anaesthetic problems
- Increased risk of difficult intubation
- Due to floppy laryngeal structures obscuring view
- Difficulty with stridor after extubation
Outline your approach to paediatric bronchoscopy.

Rigid bronchoscopy

Surgery
- Elective for investigation of masses, respiratory symptoms
- Semi-urgent for removal of foreign bodies
- Emergency for massive haemoptysis, acute obstruction
- May be moderate or high risk
- Shared airway

Preoperative
- Anaesthetic assessment
  - Routine, plus
    - Careful assessment of mouth opening and potential for dental injury
    - Respiratory function testing if adult and compromised
- Assessment of indication for bronchoscopy
  - Respiratory compromise
  - Complications of disease e.g. cachexia from tumour
- Premedication
  - Anxiolytic, amnestic agent e.g. benzodiazepine
  - Anticholinergic to reduce secretions

Induction
- Preparation of the airway
  - Local anaesthetic
    - Topical spray or nebulized lignocaine
    - Transtracheal lignocaine
    - Nerve blocks: glossopharyngeal and superior laryngeal
  - Dental guard
- Monitoring
  - Routine: SpO₂, ECG, NIBP
  - Plus arterial line if debilitated
  - Secure IV access for TIVA
- Induction
  - Propofol plus short-acting relaxant (rocuronium or suxamethonium)
  - Fentanyl to blunt haemodynamic response to bronchoscopy
- Ventilation
  - Jet insufflation through scope
    - Requires special equipment
    - No anaesthetic agent delivered so requires TIVA
    - Permissive hypercapnea limits duration of procedure
      - ↑ risk of arrhythmias
    - Risk of barotrauma if scope occluded
  - IPPV through scope
    - T-piece circuit
    - Allows delivery of volatile agent
    - Intermittent ventilation as scope must be occluded
      - So high FiO₂ to allow for apnoea
    - Requires good communication with surgeon
- HFJV
  - Spontaneous ventilation without relaxant
- Maintenance
  - Intermittent boluses of IV anaesthetic agent and relaxant or infusion
  - Extreme vigilance for ventilatory compromise
- Emergence
  - May require intubation and suctioning after procedure until awakening and muscle relaxant reversal
Lateral position
Risk of haemoptysis after resection or biopsy

Postoperative
Usually little analgesia required
Supplemental oxygen and saturation monitoring

Particular considerations in paediatric bronchoscopy
Patient population
Commonly performed for foreign body aspiration
Usually fibreoptic scope is not an option
Often semi-urgent
Higher metabolic rate, low FRC
Rapid onset of hypoxia
Particularly good communication with surgeon required

Airways
Smaller calibre and softer tissue
Increased risk of perforation or bleeding
Increased risk of laryngospasm during emergence
Management of anaesthesia for a teenage scoliosis patient

Surgery
Elective, high risk surgery
Usually in teenage females
Extensive thoracotomy, potential for massive blood loss, hypothermia
Posterior and anterior approaches
May have coexisting neuromuscular disease
Secondary respiratory or cardiovascular compromise
Increased incidence of MH in this patient population

Preoperative
Assessment
Routine history and examination, plus
Scoliosis
Airway assessment vital
Degree, mobility
Complications
Respiratory function testing, restrictive deficit
Exercise tolerance
Investigations
FBE, XM, RFT, ABG
Autologous blood donation or directed donation
Consent
Discussion of risks
Possible need to wake intraoperatively to test neurological function
Premedication
Oral benzodiazepine with regard to respiratory function
Transport
Routine

Intraoperative
Monitoring and access
Usual emergency equipment, plus
Difficult airway equipment
Rapid infusion equipment available
Cell saver if indicated
Routine monitoring, plus
Arterial line, temperature probe, IDC
SSEP or MEP monitor
Availability of ABG and Hb measurements
Induction
Intubation required
Thoracotomy and commonly prone
Prepare for difficult airway if likely
Consider spontaneously breathing induction or awake FOB if required
Otherwise routine IV induction
Short-acting muscle relaxant if MEP required
Maintenance
Position
Pressure care may be difficult if severe scoliosis
Often prone, avoid abdominal pressure causing vertebral vein engorgement
Ventilation
\( \text{N}_2\text{O}, \text{O}_2, \) low isoflurane dose
\( \pm \) propofol for intraoperative awakening
Controlled hyperventilation to cause vasoconstriction
One lung often retracted for surgical access: OLV
Circulation
  May be large blood loss
  Maintain normotension for cord perfusion
  Fluid loading and pressors
Analgesia
  Consider spinal or caudal morphine either by surgeon or pre-incision
  Fentanyl bolus plus infusion
Emergence
  Awake extubation, lateral position
  May require ICU ventilation if severe respiratory compromise
  Aim for early assessment of neurological function
  Consider propofol “bookend”
Supplemental O₂
Postoperative CXR and FBE
Prolonged immobilization in supine position
  Chest physiotherapy, ?DVT prophylaxis
Outline the management of anaesthesia for tracheoesophageal fistula surgery.

Tracheoesophageal fistula

1/3000 live births
Abnormal communication between oesophagus and trachea
Usually associated with oesophageal atresia
Classified by topology
  85% distal TOF with proximal blind oesophagus
  10% oesophageal atresia with no TOF
  4% patent oesophagus with TOF (often diagnosed late)
Diagnosed shortly after birth
  Associated with polyhydramnios
  Failure to pass orogastric tube
  Failure to feed or aspiration with feeding
Surgical management
  IV hydration
  Laparotomy, feeding gastrostomy, determination of “gap”
  Thoracotomy, fistula closure, oesophageal repair

Surgery
  Urgent, high risk

Preoperative
  Assessment
    History
      Post-conceptual age, gestational problems
      Family history
      Diseases of prematurity
      VATER abnormalities
        Vascular (cardiac), vertebral, atresia in GI tract, TOF, renal, radial abnormalities
    Examination
      Cardiac, respiratory, general
      15-25% incidence of cardiac defects
      Aspiration common
    Investigation
      XM, FBE, U&E or gases
      CXR
      Contrast studies
      Echocardiogram
  Optimization
    Hydration, antibiotics for pneumonia, treatment of lung disease
  Premedication
    Atropine, paracetamol, antibiotics

Intraoperative
  Monitoring
    Routine: ECG, NIBP, SpO₂, gas analysis, IDC
    Consider arterial line if unstable or blood gases required
    Temp probe not in oesophagus
  Induction
    Aim to avoid mask IPPV which causes gastric distension
    Bradycardia and diaphragmatic splinting
    Aspirate gastrostomy and leave open
    Topical LA to airway
    Inhalational induction, spontaneously breathing intubation, or
    Rapid IV induction
    ETT placement beyond level of TOF, may be at carina
Maintenance
  Position
    Laparotomy at 45° head-up
    Thoracotomy in left lateral position unless right aortic arch (5%)
  Warming to maintain temperature
  High FiO₂ with potent volatile agent
  Hand ventilation often required
    ETT may migrate into fistula with positioning
  Low lung compliance
  Gas leak through fistula
  Retraction of right lung for access
  Retraction on mediastinum may cause tracheal occlusion
  Analgesia with LA in wound or intercostal blocks
  Close attention to blood loss and fluid management

Emergence
  Aim for extubation if stable
  Less stress on tracheal sutures than IPPV
  Avoid neck extension: stresses anastomosis

Postoperative
  NICU or neonatal unit level of care
  SpO₂ monitoring
  Morphine infusion for analgesia
  Complications
    Pneumonia, anastomotic leak, tracheomalacia, fistula, reflux, stricture
Paediatric respiratory failure

Definition
- \( \text{PO}_2 < 60 \text{ mmHg, PCO}_2 > 55 \text{ mmHg, RR} > 35 \)
- at BTPS, \( \text{FiO}_2 0.21 \), worse than normal function
Type 1 ventilation failure, acidic pH (raised \( \text{PCO}_2 \))
Type 2 oxygenation failure, normal pH

Diagnosis
- Very broad range of clinical symptoms, essentially subjective
- Apnoea
- Increased work of breathing, other clinical features
- Tachypnoea, but rate highly variable and not different between well and ill populations
- Cyanosis
- ABG criteria

Susceptibility of children
- Less reserve, higher BMR for size
- Small airways, less adherent mucosa, readily occluded by oedema
- Narrow subcricoid level, airways cause 20% of resistance
- Short horizontal ribs, little increase in AP chest diameter
- Soft chest wall, poor inspiratory pressure generation
- Type I muscle fibres, easily fatigued
- Less alveoli, continued budding to age 1y
- Few pores of Kohn, more variation in time constants
- Increased susceptibility to infection, poor cellular immunity, no memory IgG response
- Birth injuries: asphyxia, aspiration, RDS of newborn

Differences from adults
- Adults recover slowly if at all (80% mortality)
- Children require only brief ventilation (3-4 days), good outcomes (5-6% mortality)
- Most deaths in neonates

Analysis
- Cost per year independent life saved
  - Neonate $1500, child $170, adult $1950
- Cost per survivor
  - Neonate $95500, child $11500, adult $27850
- Cost per patient intubated
  - $28650, $8600, $9750

Causes of respiratory failure in children
- Epiglottitis
  - Marked decline due to haemophilus influenzae B vaccination
- Croup
  - Nebulized adrenaline 0.5 ml/kg of 1:1000 or 0.05 ml/kg of racemic (1:88)
  - Steroids
- Bronchiolitis
- Asthma

Treatment
- Ventilation
  - HFPPV
    - 60-100 /min 3-4 ml/kg small dead space
    - pressure generator with "chopper"
HFJV
similar to Sanders jet ventilator
3-5 ml/kg intermittent
Trial evidence suggests benefit in neonates by intermediate indicators

HFOV
3-15 /sec alternates between positive and negative pressure
less than dead space ventilation
rescue ventilation
set rate, Δ P, mean airway pressure (FiO₂, usually .9-1.0)
CO₂ elimination better with high Δ P, low frequency
Mechanism of ventilation
  Pendelluft: differing time constants
  Assymetric velocity profiles: wave interference between in and
  out flow at joints
  Taylor dispersion: wave diffusion at joints?
  Molecular diffusion: simple diffusion
Trial (HIFI) showed no benefit, but done in centres inexperienced with
HFOV. Increased IVH, PVL rate. Less risk of long term disease, fibrosis,
ECMO etc.
Surfactant and NO can be delivered
Conventional ventilation is usually the first strategy as HFJV and HFOV are
not available in obstetric hospitals

ECMO
Available if failed ventilation, correctable disease, 80% expected mortality
Physiological indices also determine entry
Anticoagulation problems
Femoro-femoral or femoro-atrial
Ventilation for lung recruitment
Common sizes and doses

Weight

- **Birth**: 3-4 kg
- **1 y**: 10 kg
- **age x 2 + 9**: up to 9 y
- **age x 3**: from 9 y

ETT size

- **Prem**: 2.5 mm
- **Term**: 3-3.5 mm
  - 9 cm at lips
  - age ÷ 4 + 4 ≤ age + 10 cm at lips (or age ÷ 2 + 12)

Induction (single agent unpremedicated elective)

- **Thiopentone**: 7 mg/kg
- **Propofol**: 4 mg/kg
- **Ketamine**: 2 mg/kg
- **Suxamethonium**: 1.5-2 mg/kg
- **Atracurium**: 0.5 mg/kg
- **Atropine**: 10-20 µg/kg
- **Morphine**: 0.1-0.2 mg/kg
- **Fentanyl**: 1-3 µg/kg
- **ß-lactams**: 20 mg/kg
- **Metronidazole**: 15 mg/kg
- **Gentamicin**: 6 mg/kg (less <1 y)
- **Reversal**
  - **Neostigmine**: 50 µg/kg
  - **Atropine**: 24 µg/kg

Resuscitation

- **Adrenaline**: 10 µg/kg up to 100 µg/kg
- **Calcium**: 0.1-0.15 mmol/kg (0.2 ml/kg CaCl₂, 0.5 ml/kg Ca gluconate)
- **DCR**: 2-4 J/kg (1 J/kg for atrial arrhythmia)

Hypotension

- **Nitroprusside**: 50 mg/500 ml 0-20 ml/h (=0-33 µg/min, 0-10 µg/kg/min)
Neonatal Resuscitation (from Sydney Simulation Centre notes)

Intrauterine asphyxia is hypoxia, hypercarbia and metabolic acidosis
Neonates tolerate hypoxia well, but not ischaemia

Priorities (A, B, C)
- Establish an oxygenated resting volume in the lungs
  - No first breath = no point in cardiac massage
- Establish circulation
  - Stroke volume does not increase in bradycardia
  - Cardiac output is rate dependent

Assessment
Newborn babies can be assessed on three criteria
- Colour
  - Pink, blue or white
- Breathing
  - Adequate or inadequate (a crying baby has an airway)
- Heart rate
  - Fast or slow

Intervention
Pink, breathing, tachycardic babies
Dry and keep warm
Blue, inadequately breathing, tachycardic babies
Basic resuscitation
  - Airway opening, bag and mask with oxygen
  - The first few breaths are recruitment breaths
Blue or white, apnoeic, bradycardic babies
Advanced resuscitation
  - Intubation and ventilation
    - 3.0 ETT
  - Cardiac massage
  - Adrenaline
    - 30 µg (0.3 ml of 1:10000) via ETT, IV, IO plus 2 ml flush saline
  - Volume
    - 30 ml saline

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