Pediatric Anesthesia

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Introduction

It is often said that **paediatric** patients are '**not simply small adults**'. The truth is that from the premature neonate to the near-adult adolescent, children are very diverse.

Pediatric patients ***involves*** the fallowing age groups :-

1.**Neonates** (0–1 months).

2.infants (1–12 months).

3.toddlers (12–24 months).

4.young children (2–12 years of age).

Pediatric anesthesia have differing anesthetic requirements. **physiological**, **anatomical**, and **pharmacological** characteristics of each group .

Indeed **infants** are at much greater risk of anesthetic morbidity and mortality than older children; **risk** is generally inversely proportional to **age**.

Estimation of weight

It is essential that every child is **weighed** prior to anaesthesia. This allows correct calculation of **drug doses** and selection of anaesthetic **equipment**. Weight can also be estimated from the age of the child from **standard growth charts**, from the **length of the child**, or using this **formula**:

Age of child	Formula to estimate weight in kg
0-12 months	(0.5 x age in months) +4
1-5 years	(2x age in years) +8
6-12 years	(3x age in years) +7

Anatomical & Physiological Differences

1-Respiratory System Differences

- The major anatomical differences affecting **airway management** in neonates and infants are:
- Relatively **large head** and prominent occiput
- **Small mandible**
- Relatively **large tongue**
- **Short neck**
- **narrower nasal passages** and
- **anterior** and **cephalad larynx**.
- a longer epiglottis and a shorter trachea.
- **Soft tracheal cartilages** easily compressed.

These differences predispose to **airway obstruction**, particularly if the child's head is placed on a pillow, or the soft tissues on the floor of the mouth are compressed, or the head is hyperextended. **Ideally**, maintain the child's head in a **neutral** position, or **slightly** extended.

Anatomical & Physiological Differences

Anatomical differences affecting the larynx include:

- A **high**, anterior position of the larynx (level of **C3-4** in infants compared to **C5-6** in **adults**)
- A **long**, **U-shaped epiglottis**
- The **narrowest part** of the airway is at the **cricoid cartilage** (below the vocal cords).
  - The **narrowest part** of the airway in **adults** is at the **vocal cords**.

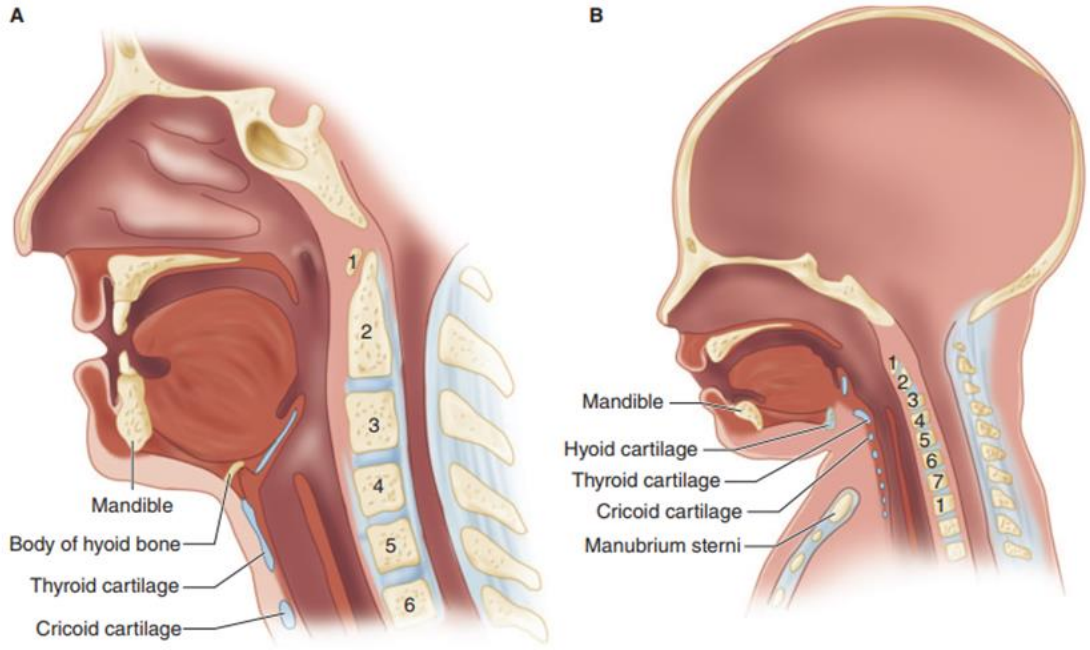

FIGURE 42–1 Sagittal section of the adult (**A**) and infant (**B**) airway. (Reproduced with permission from Snell RS, Katz J. *Clinical Anatomy for Anesthesiologists*. New York, NY: Appleton & Lange; 1988.)

Anatomical & Physiological Differences

The major physiological differences in respiratory system.

- **Faster** respiratory **rate.**
- **Lower lung compliance.**
- **Greater chest wall** compliance.
- **Lower** functional residual capacity.
- **high** metabolic rate and oxygen consumption.

Note: children **tidal volume** is relatively **fixed** (5-7 ml.kg-1), and the infant can **only** increase minute ventilation by increasing **respiratory rate**.

- **Apnoeas** are particularly **common** in **premature** and **ex-premature infants**, so monitor all babies for apneas after surgery; until they are 60 weeks post conception.
- If a mechanical ventilator is used, select the appropriate tidal volume and respiratory rate for age – **pressure control ventilation is preferred.**

Anatomical & Physiological Differences

2-Cardiovascular considerations

- **Residual fetal circulation.**
- **Noncompliant left ventricle** : so increase in **cardiac output** is achieved through an increase in **heart rate** (Heart-rate-dependent cardiac output).
- **Faster** heart rate: It is important to **avoid bradycardia**. This should be treated rapidly if it occur; the most **common cause** is **hypoxia.**
- **Lower** blood pressure

Age-related changes in vital signs.

Age	Respiratory Rate	Heart Rate	Arterial Blood Pressure	
			Systolic	*Diastolic*
Neonate	40	140	65	40
12 months	30	120	95	65
3 years	25	100	100	70
12 years	20	80	110	60

Anatomical & Physiological Differences

2-Cardiovascular considerations

- Activation of the **parasympathetic** nervous system by anesthetic **overdose**, or **hypoxia** can quickly trigger **bradycardia** and profound reductions in **cardiac output**.
- **Bradycardia** that can lead to **hypotension**, **asystole**, and intraoperative **death**.
- The **immature heart** is more sensitive to depression by **volatile anesthetics** and to **opioid-induced** bradycardia.
- **The main causes of neonatal bradycardia and cardiac arrest during anesthesia are:-**
- ✓ **Respiratory causes** :- airway obstruction, bronchospasm, inadequate O2 delivery.
- ✓ **Pharmacology causes** :-inhalation agents, succinylcholine, anticholinesterase.
- ✓ **Metabolic causes**:-hypothermia, anemia, hypoglycemia.
- ✓ **Children are more** susceptible than adults to **cardiac arrhythmias, hyperkalemia, masseter spasm, and malignant hyperthermia associated with succinylcholine.**
- ✓ When a child experiences cardiac arrest following administration of **succinylcholine**, immediate treatment for **hyperkalemia** should be instituted

Anatomical & Physiological Differences

3 . Metabolism & Temperature Regulation Differences.

Neonates promote greater **heat loss to the environment** and liable to hypothermia **Because:-**

1. **Thin** skin.
2. **Low** fat content.
3. **Greater** surface area relative to weight.
4. **Inadequately** warmed operating rooms (cold theater).
5. **Prolonged** wound exposure.
6. Administration of room temperature intravenous or irrigation fluid.
7. **Dry** anesthetic gases
8. Effects of anesthetic agents on temperature regulation center.

Even mild degrees of hypothermia can cause perioperative problems which including:-

- Delayed awakening from anesthesia.
- Cardiac irritability and arrest.
- Respiratory depression.
- Altered responses to anesthetics and Neuromuscular blockers, and other agents.

Anatomical & Physiological Differences

4-Renal & Gastrointestinal Function Differences

- The **total body water** is about **80**% of body weight at birth, gradually **decreasing** with **age**. fluid loss are more critical problem to them.
- **Immature kidney function** increases the importance of meticulous attention to fluid administration in the early days of life
- **Neonates also have a relatively increased incidence of gastroesophageal reflux.**
- **The immature liver conjugates drugs and other molecules less readily early in life.**

5-Glucose Homeostasis Differences

- Neonates have relatively **reduced glycogen stores**, predisposing them to **hypoglycemia**.

6-Pharmacological Differences: The main difference prolongs the clinical duration of action of drugs such as **thiopental** and **fentanyl**. this Bec:-

1.larger pediatric intravascular and extracellular fluid **compartments** compare with adult . Neonates and infants have a proportionately greater total water content than adults (50–60%).

2.Immaturity of hepatic **biotransformation** pathways,

3.Decreased protein for drug binding .

4.Smaller muscle mass in neonates **prolongs** or delaying redistribution of some drugs such as thiopental and fentanyl.

Some Pharmacological considerations

Volatile anesthetics

- Neonates are more sensitive to volatile agents than older children
- The minimum alveolar concentration (**MAC**) values are decreased in neonates but increased in infants and children compared to adults.

Sedatives and hypnotics

Children are particularly sensitive to sedative and hypnotic drugs such as **barbiturates** and **benzodiazepines** due to the **Immature hepatic biotransformation** and **Decreased protein binding** so these drugs should be used with caution, in weight appropriate doses, titrated according to effect.

Muscle relaxants

Neonates and **infants** are **more sensitive** to **non-depolarizing neuromuscular blocking** drugs **because** Immature neuromuscular junction.

A normal **loading dose** is given but **subsequent** doses should be reduced

ANAESTHETIC MANAGEMENT

Preoperative Preparation

- All children should be visited preoperatively by the anesthetist responsible for caring for them in the perioperative period.
- There is an increased incidence of airway problems during anaesthesia
- children are more at risk of laryngeal spasm, breath-holding and bronchospasm
- in the postoperative period the chance of *post-intubation croup is increased*.
- It is ***extremely important*** that the *child is weighed before arrival in theatre*, because body *weight* is the simplest and *most reliable guide to drug dosage*.
- Veins suitable for insertion of a cannula should be identified.

ANAESTHETIC MANAGEMENT

Preoperative Fasting

- Morbidity and mortality caused by aspiration of gastric contents are extremely rare in children undergoing elective surgery.
- **Prolonged** periods of **starvation** in children, especially the very young infant, are **harmful**.
- These children, who have a rapid turnover of fluids and a high metabolic rate, are at risk of developing **hypoglycemia** and **hypovolemia**.
- **Solids** (including breast and formula milk) should not be given for **at least 6 h before** the anticipated start of induction.
- In the **emergency** setting, e.g. the child who has sustained trauma shortly after ingesting food, **it is probably best (if possible) to wait 4 h before inducing anaesthesia.** Clearly, in this situation risk–benefit judgements have to be made.
- If it is surgically possible to wait 4 h, an i.v. infusion of a **glucose-containing solution** such as **5% dextrose** with **0.9% NaCl**, must be commenced and, if necessary, appropriate fluid resuscitation undertaken.

ANAESTHETIC MANAGEMENT

Intravenous Induction

- The same induction sequence can be used as in adults: a rapid-acting barbiturate (eg, thiopental, 3 mg/kg in neonates, 5–6 mg/kg in infants and children) or propofol (2–3 mg/kg) followed by a non-depolarizing muscle relaxant (eg, rocuronium, cisatracurium, atracurium, mivacurium, or succinylcholine).
- Atropine should be given intravenously prior to succinylcholine.
- It is important that children are accompanied into the anaesthetic room by someone with whom they are familiar.
- The appropriate monitoring should be applied as soon as possible **after** the start of anaesthesia.

ANAESTHETIC MANAGEMENT

- When inhalational induction is planned, ***clear***, *scented plastic masks* are much more acceptable to small children than the traditional **Rendell–Baker rubber masks**.
- ***Clear masks*** allow respiration and the presence of vomitus to be observed.
- An alternative to using a mask is cupping the hands over the face of the child while holding the T-piece, It is important to ensure that the flow of fresh gas is **directed away** from the child's **eyes** because anaesthetic gases may be irritant.
- When using a face mask, it is important that the soft tissue behind the chin is not pushed backwards by the fingers, thereby obstructing the airway. **The anaesthetist's fingers should rest only on the mandible.**

ANAESTHETIC MANAGEMENT

Airway Management

The Jackson–Rees modification of the Ayre's T-piece

- is the breathing system used traditionally for children under **20 kg** in weight.
- It has been designed to be **lightweight** with a **minimal** apparatus dead space.
- may be used for both **spontaneous** and **controlled** ventilation

The **open-ended** reservoir bag is used for manually controlled ventilation. This mode of ventilation is especially useful in the neonate and infant.

- Laryngeal mask airway (**LMA**) should be used **only** when it is planned that the child is to breathe **spontaneously** during surgery. It follows that **it is unwise** to use the device when neuromuscular blocking drugs are used.
- It is **mandatory** to intubate the trachea during **artificial** ventilation.
- Neonates with a tracheal tube must undergo artificial ventilation **in order to** *reduce the work of breathing.*
- **Infants** have a head which is **large** and a neck which is **short** relative to the size of the body. Instead of placing a pillow under the head, ***it is usually necessary to place a small pad or pillow under the torso.***

Airway Management

Tracheal intubation

For children over 1 year:

Appropriate tube internal diameter (ID) can be approximately estimated by the formula: age / 4 + 4.

Appropriate tube length in cm. can be approximately estimated by the formula: age / 2 + 12 oral (+15 for nasal).

In infants:

Appropriate tube ID sizes for preterm: <1500 g = 2.5 mm, 1500-3000 g = 3 mm, over 3000 g = 3.5 mm.

Oral length in cm. is given by the formula (6 + weight in kg).

Laryngeal mask airway (LMA): They are useful in short procedures with spontaneous ventilation. They have less resistance than endotracheal tubes and are of considerable use for insertion of fiberoptic bronchoscopes. Approximate sizes are:

- **1 for less than 6.5 kg.**
- **2 for 6.5-20 kg.**
- **2.5 for 20-30 kg.**
- **3 for 30 kg and above.**

A size 1.5 is also available.

The armored versions have reduced risk of kinking and are longer and narrower.

Airway Management

If too **large** a tube is selected, the tracheal mucosa is **damaged** and the child may develop **post-intubation croup**;

If it is **too small**, excessive **leak** makes effective positive pressure ventilation impossible

Generally, **cuffed tubes** are used only in children **above** the age of **8 years**.

Adequate **preoxygenation** may help prevent hypoxemia.

A prominent occiput tends to place the head in a ***flexed position*** prior to intubation. This is easily corrected by *slightly elevating the shoulders with towels*.

Straight laryngoscope **blades** aid intubation of the **anterior larynx** in neonates, infants, and young children.

Mucosal trauma from trying to force a tube through the cricoid cartilage can cause postoperative **edema**, **stridor**, **croup**, and **airway obstruction**.

Inhalational Induction

- Modern **potent volatile** anesthetics can render small children unconscious within
minutes. This is usually easier in children who have been **sedated** prior to entering the operating room and who are sleepy enough to be anesthetized without ever knowing what has happened (***steal induction***).
- ***Inhalational Induction***
- Equipment appropriate for age and size should be selected.
- Typically, the child is coaxed into breathing an odorless mixture of nitrous oxide
(70%) and oxygen (30%). **Sevoflurane** is added to the anesthetic gas mixture in **0.5**% increments every **three** to **five** breaths.
- **Sevoflurane** consider ***the agent of choice for inhalation induction***.

Maintenance

- Ventilation is usually **controlled** during anesthesia of **neonates** and **infants**.
- During **spontaneous** ventilation, even the low resistance of a circle system can become a significant obstacle for a sick neonate to overcome.
- For patients weighing **less than 10 kg, it's** preferred to use the **Mapleson D** circuit or the **Bain system** because of their low resistance and light weight.
- **The circle system** can be safely used in patients of all ages if ventilation is controlled.
- Anesthesia can be **maintained** in pediatric patients with the same agents as in adults.

Maintenance

- **Isoflurane** Can be use following a **sevoflurane** induction to help **reduce** the likelihood of postoperative **delirium or agitation on emergence**.
- If **sevoflurane** is continued for maintenance, administration of an **opioid** (eg, fentanyl 1–1.5 mg/kg) 15–20 min before the end of the procedure can reduce the incidence of emergence delirium and agitation.
- Although the **MAC is higher in children** than in adults, neonates may be particularly susceptible to the cardiodepressant effects of general anesthetics. Nondepolarizing muscle relaxants are often required for optimal surgical conditions.

Perioperative Fluid Requirements

- Fluid therapy can be divided into **maintenance**, **deficit**, and **replacement** requirements.

  MAINTENANCE FLUID REQUIREMENTS

  Maintenance requirements for pediatric patients can be determined by the **4:2:1 rule**: 4 mL/kg/h for the first 10 kg of weight, 2 mL/kg/h for the second 10 kg, and 1 mL/kg/h for each remaining kilogram.

DEFICITS

- In addition to a maintenance infusion, any preoperative fluid deficits must be replaced. Calculated as (**maintenance fluid x starvation hours**) For example, if a **5-kg** infant has not received oral or intravenous fluids for **4 h** prior to surgery, a deficit of 80 mL has accrued (5 kg x 4 mL/kg/h x 4 h).
- Preoperative fluid deficits are typically administered with hourly maintenance requirements in aliquots of **50%** in the **first hour** and **25**% in the **second** and **third**
  hours. In the example above, a total of 60 mL would be given in the first hour (**80/2** + **20**) and **40** mL in the second and third hours (80/4 + 20).
- **Preoperative fluid deficits are usually replaced with a balanced salt solution (eg, lactated Ringer's injection) or ½ normal saline.**

REPLACEMENT REQUIREMENTS

- Replacement can be subdivided into blood loss and third-space loss.
  Blood Loss
- **Blood** loss is typically replaced with non-glucose-containing crystalloid (e.g., 3 mL of lactated Ringer's injection for each milliliter of blood lost) or colloid solutions (eg, 1 mL of 5% albumin for each milliliter of blood lost).

THANK YOU