Anaesthesia for Pediatric

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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 Age Group Classification :

1. **Neonates** (0–1 months). Up to 44 weeks post conception (includes premature neonates)

2. **Infants** (1–12 months). From 44 weeks post conception – 1 year

3. **Toddlers** (12–24 months).

4. **Young children** (2–12 years of age).

Introduction :

- Pediatric anesthesia has differing anesthetic requirements. physiological, anatomic, 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:

Estimation of weight :

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
  - Relatively **large tongue**
  - **Small mandible**
  - **Short neck**

Anatomical & Physiological Differences :

1-Respiratory System Differences :

- narrower nasal passages, an anterior and cephalad larynx, a longer epiglottis, and a shorter trachea. These anatomic features make neonates and young infants **obligate nasal breathers** until about **5** months of age
- **Soft tracheal cartilages**, easily compressed.

Anatomical & Physiological Differences :

1-Respiratory System Differences :

- 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**

Anatomical & Physiological Differences :

Anatomical differences affecting the larynx include:

- ❖ The narrowest part of the airway is at the cricoid cartilage (below the vocal cords).
- o The narrowest part of the airway in adults is at the vocal cords.
- o Adeno-tonsillar hypertrophy is common in children 3 – 8 years of age.
- o Airway obstruction may develop after induction of anaesthesia; an oropharyngeal airway may help to maintain a patent airway.
- o Take care when passing nasopharyngeal, nasotracheal and nasogastric tubes in these children.

•Children aged 5-13 years may have loose teeth; take note of loose teeth at your pre-assessment visit

Anatomy :

Infant | Toddler | Adult

Figure 4.

The infant larynx differs markedly from the adult in size, shape, composition and position. As the infant grows, the epiglottis changes from short and omega-shaped to elongated and spade-shaped.

All images courtesy of the author.

Anatomical & Physiological Differences :

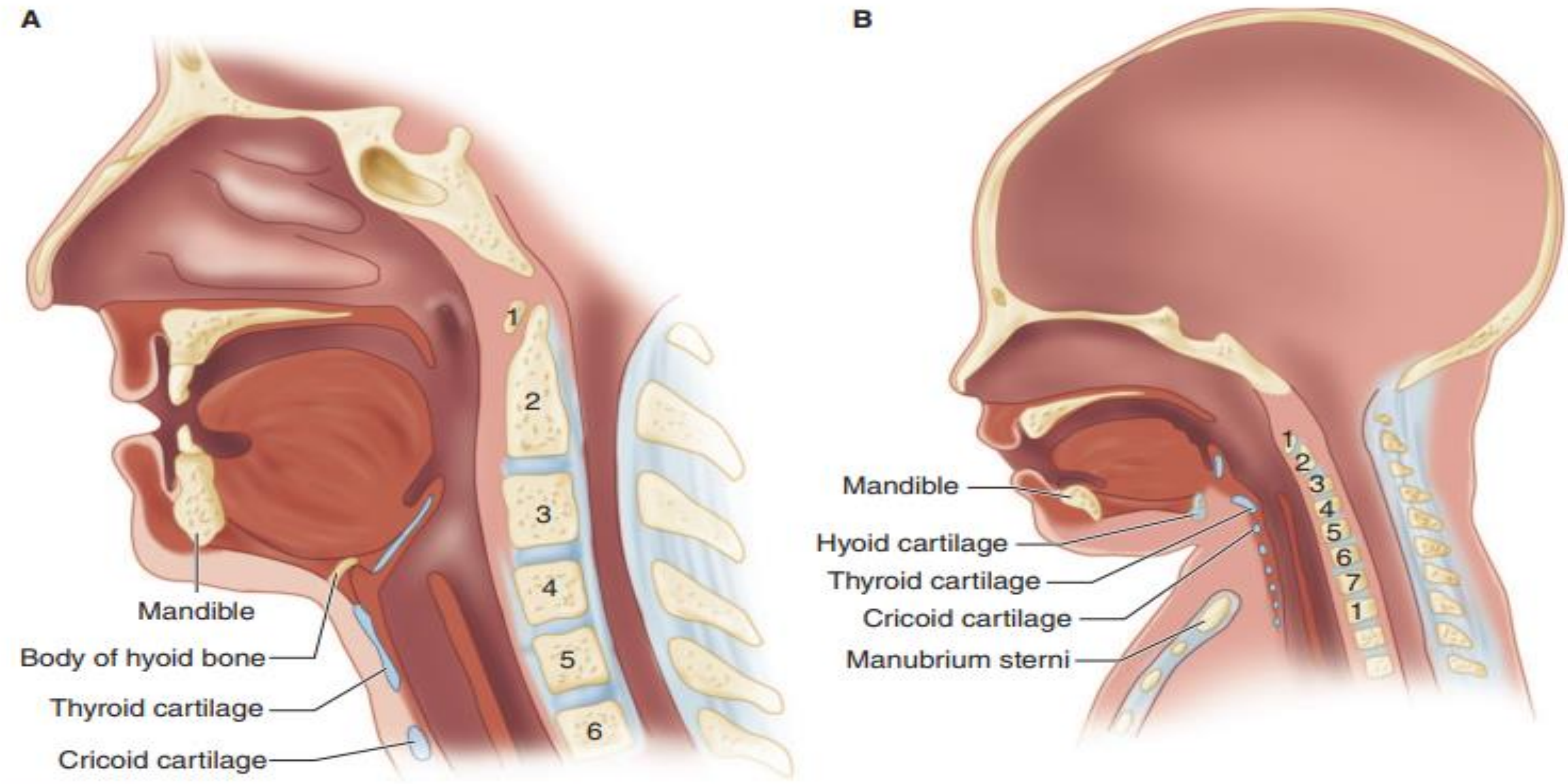

FIGURE 42–1 Sagittal section of the adult (**A**) and infant (**B**) airway. (Reproduced with permission from Snell RS, Katz J. *Clinical Anatomy for Anesthesiologists*. New York, NY: Appleton & Lange; 1988.)

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**.

Anatomical & Physiological Differences :

The major physiological differences in respiratory system :

- Apnea 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

Anatomical & Physiological Differences :

2-Cardiovascular considerations :

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.

Anatomical & Physiological Differences :

2-Cardiovascular considerations :

- ❖ 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.

Anatomical & Physiological Differences :

3. Metabolism & Temperature Regulation Differences.

4. Inadequately warmed operating rooms (cold theater)

5. Prolonged wound exposure.

6. Administration of room temperature intravenous or irrigation fluid.

6. Dry anesthetic gases

7. Effects of anesthetic agents on temperature regulation center.

Anatomical & Physiological Differences :

3. Metabolism & Temperature Regulation Differences.

•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 is 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.

Anatomical & Physiological Differences :

5-Glucose Homeostasis Differences :

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

Anatomical & Physiological Differences :

6-Pharmacological Differences :

The main difference is prolonging the clinical duration of action of drugs such as thiopental and fentanyl. this Because: -

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.

Volatile anaesthetic :

- 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

ANAESTHESIA MANAGEMENT :

Preoperative Preparation :

- All children should be visited preoperatively by the anaesthetist 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.

ANAESTHESIA MANAGEMENT :

Preoperative Preparation :

- 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.
- 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.

ANAESTHESIA MANAGEMENT :

Preoperative Preparation :

- These children, who have a rapid turnover of fluids and a high metabolic rate, are at risk of developing hypoglycaemia and hypovolaemia.
- Solids (including breast and formula milk) should not be given for at least 6 h before the anticipated start of induction.

ANAESTHESIA MANAGEMENT :

Preoperative Preparation :

- 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

ANAESTHESIA 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.

ANAESTHESIA MANAGEMENT :

Intravenous Induction :

- The appropriate monitoring should be applied as soon as possible after the start of anaesthesia.
- 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.

ANAESTHESIA MANAGEMENT :

Intravenous Induction :

- 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.

ANAESTHESIA MANAGEMENT :

ANAESTHESIA 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. The apparatus 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.

ANAESTHESIA MANAGEMENT :

Airway Management :

- 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.

ANAESTHESIA MANAGEMENT :

Airway Management :

- 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.

Position :


POSITIONING INFANTS FOR AIRWAY MANAGEMENT
Nose - Chin Axis
Wide Open
Anterior
Neck Space
Head Rest
Shoulder Roll

ANAESTHESIA 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).

ANAESTHESIA MANAGEMENT :

Tracheal intubation : LMA :

Table 34.8 Estimating the size of LMA in paediatrics

Size of LMA	Weight (kg)	Cuff volume (mL)
1	Less than 6.5	2–5
2	6.5 –20	7–10
2.5	20–30	12–14
3	>30	15–20

ANAESTHESIA MANAGEMENT :

Tracheal intubation

- 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.
- In the case of an awake intubation in a neonate or young infant, adequate preoxygenation may help prevent hypoxemia.

ANAESTHESIA MANAGEMENT :

Tracheal intubation

- 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.

ANAESTHESIA MANAGEMENT :

Inhalational Induction :

- Most children do not arrive in the operating room with an intravenous line in place.
- 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).

ANAESTHESIA MANAGEMENT :

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. Single breath induction technique with sevoflurane (7–8% sevoflurane in 60% nitrous oxide) can be used to speed up induction.
- After an adequate depth of anesthesia has been achieved, an intravenous line can be started and a muscle relaxant administered.

ANAESTHESIA MANAGEMENT :

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.

ANAESTHESIA MANAGEMENT :

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 mcg/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

ANAESTHESIA MANAGEMENT :

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.

ANAESTHESIA MANAGEMENT :

Perioperative Fluid Requirements :

- The ideal maintenance solution is 0.18% saline in 4% dextrose with added potassium chloride (KCl) 20mmol.l-1 if required)
- Neonates require 3–5 mg/kg/min of a glucose infusion to maintain euglycemia; premature neonates require 5–6 mg/kg/min.

ANAESTHESIA MANAGEMENT :

Perioperative Fluid Requirements :

•DEFICITS

- In addition to a maintenance infusion, any preoperative fluid deficits must bereplaced. 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 maintenancerequirements 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.

ANAESTHESIA MANAGEMENT :

Perioperative Fluid Requirements :

•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 (eg, 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).