Review Article

Anaesthetic concerns in preterm and term neonates

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ABSTRACT

Anaesthesia for neonates is a composite of good knowledge of neonatal and transitional physiology combined with skill in airway maintenance and vascular access. When the newborn is a preterm, the complexities of management increase due to the small size and accompanying issues such as bronchopulmonary dysplasia and apnoea. World over, the number of survivors of preterm birth is on the increase. We searched Pubmed for "Anesthesia, apnea, neonatal, neonates, physiology, preterm, spinal anesthesia", as well as cross references from review articles. These babies have a high incidence of conditions warranting surgery (e.g., tracheoesophaeal fistula, congenital diaphragmatic hernia, anorectal malformations, incarcerated hernia, necrotising enterocolitis). The possibility of neurodevelopmental harm by anaesthetics is currently the topic of active research. In parallel, advances in paediatric anaesthesia equipment, use of regional and neuraxial anaesthesia and availability of monitoring have steadily increased the safety of anaesthesia in these tiny patients.

Key words: Anaesthesia, apnoea, GAS study, neonatal, neonates, neurodevelopmental issues, outcomes, physiology, preterm, spinal anaesthesia

INTRODUCTION

The perioperative anaesthetic management of neonates is challenging even for experienced anaesthesiologist. Their small size [Figure 1] calls for skill in vascular access and airway management, and their vulnerability to respiratory and cardiac events and their immature physiological adaptation need vigilance, rapid detection and correction.[1] There are additional problems of the transitional circulation, increased presence of co-morbidities and, importantly, the occurrence of apnoea in preterms. Neonatal surgery is associated with higher mortality than older children.[2] The possible neurotoxic effect of anaesthetics on the developing neonatal brain is the subject of active research (GAS, PANDA).[3,4]

HISTORY OF PAEDIATRIC ANAESTHESIA

Till the 1980s, it was assumed that neonates feel little or no pain due to immaturity of the nervous system and it was customary to omit the use of narcotics in neonatal anaesthesia. The Liverpool technique popularised by Jackson Rees used oxygen–nitrous oxide, muscle relaxant and volatile agent for even lengthy procedures without narcotics. Seminal research by Anand *et al.* showed that neonates have dynamic physiologies and feel and respond to noxious stimuli. Perioperative stress has been related to unfavourable postoperative outcomes in neonates undergoing cardiac surgery.[5] Intrauterine exchange transfusions performed through the innervated abdominal wall of the foetus result in a greater neuroendocrine stress response compared with puncture of the non-innervated umbilical cord.[6]

AMERICAN ASSOCIATION OF PEDIATRICS (AAP) DEFINITION

The postmenstrual age (PMA) which is the sum of the *gestational age* (first day of last menstrual period to date of delivery) and chronological age (from date of birth to present) is recommended by the American Association of Pediatrics (AAP)[7] for contemporary use

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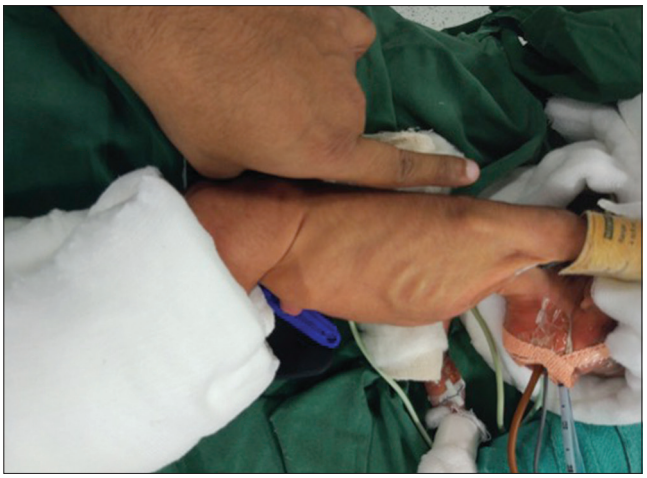

Figure 1: A 800-g premature infant positioned for tracheoesophaeal fistula repair

[Figure 2]. The terms 'post-conceptional' age (PCA) and postmenstrual age are often used interchangeably.

Premature babies are defined as those born before 37 weeks gestation and account for about 10-13% of total births in Western literature. The terminology of neonates and preterms [Table 1] is based on either gestational age or weight.[8]

Relevant points in the physiology of neonates and preterm infants[9-15] are outlined in Table 2.

Apnoea of the preterm/neonate

Periodic breathing with pauses is common in neonates and preterms. Apnoea is pathological when >20 s, or <20 s with bradycardia (30 beats/min/20% decline from resting heart rate), or with cyanosis, pallor, or hypotonia.[13,16] The incidence of apnoea varies from 25% in LBW premature to 84% in the VLBW group. Apart from active inhibitory reflexes and anaemia, which is a proven risk factor, other contributory factors are listed in Table 3.

The incidence of apnoea becomes less than 1% only after PCA of 54-56 weeks is reached, thus necessitating admission and overnight monitoring of infants <60 weeks PMA.[17] The contributing factors related to postoperative apnoea can also be used as indicators of overnight monitoring and admission.[18]

Caffeine and apnoea

Administration of 5/10 mg/kg caffeine IV preoperatively significantly reduces postoperative apnoea.[19] Caffeine stimulates the respiratory center and cardiovascular system, enhances responsiveness to CO_2, increases diaphragmatic contractility, minute ventilation

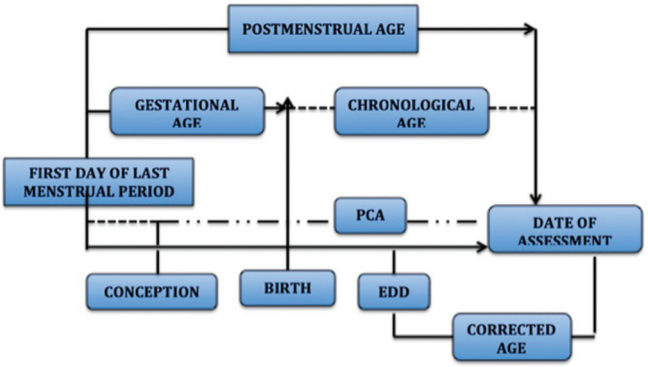

Figure 2: AAP definition of age of neonates and preterms

Table 1: Nomenclature used for classification of neonates and preterm babies

Nomenclature based on gestational age	
<37 weeks	Premature
<28 weeks	Extreme premature
Nomenclature based on weight	
<2500 g	Low Birth Weight (LBW)
<1500 g	Very Low Birth Weight (VLBW)
<1000g	Extremely Low Birth Weight (ELBW)

oxygen consumption and metabolic rate.[20] A reduction in duration of CPAP has been observed.[21,22] Neurodevelopmental outcomes may be improved and motor impairment reduced by protection of white matter.[23,24] However caffeine administration has been seen to result in lower weight gain and increased incidence of death.[25,26] A recent study advocated its administration to only infants weighing <1250 g.[27]

Preoperative evaluation

It is important to keep the parents of the infant updated regarding the condition of their child and the perioperative plan. The reasons for operation and the risks anticipated should be explained. Appropriate consent should be obtained for invasive procedures, regional anaesthesia (RA), blood transfusion and need of postoperative ventilation.

The history, apart from gestational age, current age and weight, should include salient perinatal history, for example, APGAR scores, birth asphyxia, meconium aspiration, septicaemia, requirement of oxygen therapy, high frequency oscillatory ventilation, mechanical ventilation, hypoglycaemic episodes and seizures. Evidence of congenital cardiac disease, if diagnosed, should be noted. The presence of significant ductal flow/persistent fetal circulation/decompensation should be documented. Intramuscular Vit K should be administered. Fasting status should be confirmed (2 h for clear fluids, 4 h for breast milk and 6 h for

Table 2: Physiology in the neonate and preterm infant[9-15]

System	Findings
Cardiovascular	1. Patent ductus arteriosus (PDA) more common in premature infants; normally closes 10 days to 2 weeks after birth
	May reopen whenever pulmonary arterial pressure rises (hypoxaemia, hypercarbia, acidosis or respiratory distress syndrome).
	Therapeutic strategies include administration of oxygen, prostacyclin and/or indomethacin, nitric oxide or surgical ablation, which may occasionally need to be performed in the neonatal intensive care unit (NICU).
	2. Neonatal cardiac myocytes have a combination of a) poor contractile force due to a combination of disorganised intracellular contractile proteins and a calcium-dependent immature sarcoplasmic reticulum and intracellular T-tubular system, and b) poor complianceà compromise of both early and late diastolic filling.
	3. Parasympathetic innervation of the neonatal heart is more developed compared to the sympathetic system, leading to bradycardia with stimulation.
	4. The premature heart cannot increase stroke volume and therefore cardiac output is rate dependent. Bradycardia can significantly reduce cardiac output; excess tachycardia may limit diastolic filling and stroke volume. A heart rate between 120 and 180 beats per minute is an acceptable limit for neonates after optimizing volume status.
	3. Blood pressure (BP) varies with neonate's postmenstrual age and normalises by 36 hours of age (70/50 mm Hg) in full terms
	Mean arterial pressure (MAP) should not be allowed to drop below the infant's gestational age in weeks or an absolute mean blood pressure of 30 mm Hg.
Respiratory	1. RDS frequent at <28 weeks due to reduced surfactant; maternal steroids in preterm labor may augment production.
	2. VLBW infants may require ventilation and oxygen supplementation for prolonged periods; may lead to development of BPD Increases after exposure >28 days
	3. BPD: increased oxygen requirements, reduced lung compliance, reversible airway obstruction and increased susceptibility to infections and bronchiolitis.
	4. Prolonged intubation◊ tracheomalacia, stenosis
	5. Obligate nose breathers: nasal obstruction common
	5. Tendency to airway obstruction due to large tongue, collapsible airway tissue.
	6. High oxygen consumption to meet high metabolic rate, primarily met by an increased respiratory rate
	7. Early respiratory fatigue: poorly developed diaphragm (only 10% Type I fibers), mechanically suboptimal thorax.
	8. The FRC < closing capacity; are PEEP-dependent and prone to rapid desaturation.
	9. Preterms are vulnerable to apnoea (see below).
Central nervous system and pain	In infants with open fontanelles, cerebral perfusion pressure varies in accordance with arterial blood pressure.
	The lower limit of autoregulation in infants older than 6 months is not reached till blood pressure has decreased by 40% from baseline. In younger infants it occurs when MAP decreases 20% from baseline.
	Low cerebral autoregulatory reserveà risk of both IVH and inadequate cerebral perfusion during periods of hypotension.
	Ischaemia due to hypotension àdamage of watershed areas between major cerebral blood vessels. The period immediately after anaesthetic induction, prior to surgical stimulus, is particularly vulnerable.
	IVH occurs in up to 50% of LBW and VLBW infants due to rupture of fragile capillaries within the germinal matrix. Intracerebral bleeds lead to the formation of periventricular leukomalacia.
	Contributing factors for IVH include perinatal asphyxia, respiratory distress syndrome and mechanical ventilation.
	Important to maintain mean arterial blood pressure within the limits of cerebral autoregulation for optimal cerebral protection.
	Pain pathways in neonates are integrated with somatic, neuroendocrine, and autonomic areas early in gestation.
	Hormonal responses to pain and stress may be therefore exaggerated in newborns.
Thermoregulation	1. Neonates and preterms more prone to heat loss due to:
	i) Relatively larger body surface-to-body weight ratio
	ii) Poorly developed subcutaneous tissue
	iii) Inability to use shivering thermogenesis
	2. These are partially compensated for by the unique non-shivering thermogenesis via brown fat, which is inhibited by volatile and intravenous anaesthetics.
	3. Hypothermia leads to cardiovascular stress, delays emergence from anaesthesia due to reduction in drug metabolism
	4. Warming of the operative environment of the neonate/preterm can be accomplished by:
	i) Warming of operative suite
	ii) Use of radiant warmers/forced air-warming units
	iii) Warmed intravenous and irrigation fluids
	iv) Protective wrapping
Renal and hepatic function	GFR at 25 weeks is 10% of adult (mature) values
	And 35% of mature value at birth in term neonates.
	Doubles within the first 2 weeks and reaches adult values by 2 years of life.
	3. Hepatic clearance via the P450 iso-enzymes reaches approximately 85% of adult levels by 44 weeks; adult levels are achieved by 6 months.
	4. Hepatic glycogen stores develop in the last few weeks of gestation. Premature infants are prone to hypoglycaemia if exogenous glucose is not administered.

Contd..

Table 2: Contd...

System	Findings
Blood volume and Pharmacokinetics	Total body water (TBW) is 75% and blood volume 85mL/kg in term neonates.
	Preterm infants have a high total body water (TBW) content [>80%body weight], with >50% as extra-cellular fluid (ECF) and blood volume 90-100 ml/kg
	Results in an apparent increase in volume of distribution
	Loading dose of drugs needs to be increased; reduced binding to albumin and α acid-glycoprotein leads to increased free drug concentration
	Drug action may be prolonged due to immature enzyme systems, impaired renal excretion and hypothermia
	Fluid requirements increase over the initial days after birth (60, 80, 100,120 mL/kg/day at day 1, 2, 3, and 4 respectively), and then remain at 150 ml/kg/day.
Coagulation	Levels of most pro- and anticoagulant proteins are low in the fetus
	These may lead to prolongation of laboratory tests such as prothrombin time (PT), thrombin time (TT), and activated partial thromboplastin time (APTT)
	Low levels of procoagulants are balanced with lower levels of inhibitors and lower activity of the fibrinolytic system
	Healthy premature neonates over 30 weeks gestation have slightly lower levels of coagulation factors and longer coagulation tests compared with term neonates; more prematures may have even less
	Neonates have a wide 'normal' range and the physiological prolongation observed does not indicate a bleeding tendency/need to correct
	Surgical neonates and preterms are at greater risk of bleeding due to low levels of procoagulants and need routine administration of Vit K.
Hematopoietic system	A term baby has a Hb value of 18-20g/dl. Although nearly 60% is Hb F, the neonate's high blood volume and cardiac output compensate for the reduced ability of HbF to release oxygen.
	In the preterm, the concentration of HbF may approach 70-80%, and Hb% is lower (13-15 g/dl).
	To facilitate oxygen delivery it is necessary to target the hematocrit to 40-45%.

RDS – Respiratory distress syndrome; VLBW – Very Low Birth Weight; BPD – Bronchopulmonjary dysplasia; FRC – Functional residual capacity; PEEP – Positive end-expiratory pressure; IVH – Intraventricular haemorrhage; LBW – Low birth weight; GFR – Glomerular filtration rate; Hb – Haemoglobin

Table 3: Factors contributing to/associated with apnoea of the newborn

Hypoglycaemia
Hypoxia
Hypothermia
Hypoglycaemia
Low gestational age
Complicated past medical history: bronchopulmonary dysplasia, necrotizing enterocolitis, apnoea at home

formula feed). Surgical colleagues should be consulted for concerns regarding surgery with respect to timing, duration, blood loss and postoperative support. This is especially important when the premature infants are operated upon by specialists other than paediatric surgeons [e.g., ophthalmic surgery for retinopathy of prematurity (ROP)].

The infant should be examined for any obvious syndromic facies which can portend airway difficulties. Careful observation for signs of respiratory distress (alar flaring, intercostal/subcostal recessions/tachypnoea) is important; capillary fill, color and turgor of skin, presence of mottling, moistness of mucosa (tongue) and BP indicate adequacy of volume status. Dehydration, if present, should be aggressively corrected.

Careful auscultation should be performed for cardiac murmurs and lung fields. Airway patency and stability should be ascertained. If the infant is on a ventilator, the settings should be noted, along with a recent arterial blood gas and chest X-ray to verify the tube position. The adequacy of vascular access is very important. The functioning and patency of current IV/arterial access devices should be noted; if vascular access is inadequate for the planned procedure, a plan should be made for central vascular access after induction of anaesthesia. All infusions and rates should be noted. All IV/arterial catheters should be protected as they are notorious to get misplaced.

Laboratory and other investigations: The 'normal' values for a neonate

All preoperative laboratories should be scrutinised. Anaemia should be corrected. Low platelet counts and increased international normalised ratio should prompt evaluation and correction of coagulopathy. The electrolytes and acid base status should be optimised. Special attention is to be paid to the potassium levels to avoid inadvertent hyperkalaemia with transfusion. Hypoglycaemia, hyponatraemia, hypernatraemia, hyperkalaemia, hypocalcaemia and hypomagnesaemia are all common in premature infants.[10] The glucose levels with the current infusion composition and rate should be noted. Packed red blood cells should be arranged for anemic infants and where surgical losses are expected [Figure 3].

Cranial/spinal/renal ultrasound/echocardiography results should be available in specific cases.

Equipment

It is extremely important to check whether appropriate airway equipment, with back-up devices, are in place prior to commencing the induction of the neonate or preterm infant.

Facemasks with minimum dead space and oropharyngeal airways should be available. The sizes of the oropharyngeal airways are 000-00 for preterms and 0 for term neonates.

Conventional laryngoscopes, with straight/curved blades of right size, should be ready, as also videolaryngoscopes. Videolaryngoscopes, especially C-MAC have greatly facilitated intubation in preterms and small babies [Figure 4]. Endotracheal tubes with correct sized stylets should be available. Choice of appropriate tube size is provided in Table 4.

Anaesthesia circuits

Although the paediatric circle system can be used in babies weighing 1 kg (workstations can deliver tidal volumes ≤10 ml), a survey showed that the modified Mapleson E is still the preferred system used by UK members of the APA for smaller children.[28] However, its use has become less now because of concerns of atmospheric pollution and availability of ventilators.

Table 4: Endotracheal tube size and length based on weight

Weight (kg)	Tube Size (ID), mm	Oral Length (cm)	Nasal Length (cm)
<0.7	2.0	5	5
<1.0	2.5	5.5	7.0
1.0	2.5/3.0	6.0	7.5
2.0	3.0	7.0	9.0
3.0	3.0/3.5	8.5	10.5
3.5	3.0/3.5	9.0	11

ID – Internal diameter

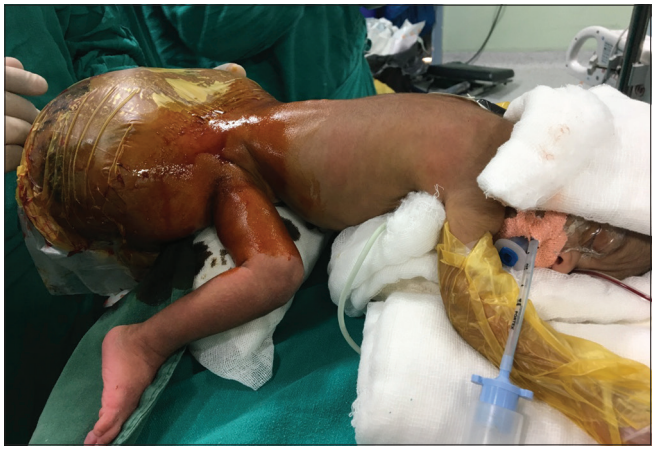

Figure 3: Preterm infant with large sacrococcygeal teratoma

Warming of the operation room

Heat loss is a major concern in the term and preterm neonates. The lack of keratin in the preterm's skin enhances heat loss. The operation room (OR) should be warmed to 27°C before receiving the baby.[12] All exposed parts should be covered with waterproof dressing ('cling wrap' or foil). A warming mattress and forced air warming must be available. IV fluids and inspired gases should be humidified and warmed.

Monitoring

Standard monitoring should be in place. All inotrope infusions, if in use, should be connected, as also glucose-containing fluids, to prevent any deterioration during induction, especially in sick babies coming from the NICU. A pulse oximeter should be applied wherever a satisfactory trace is obtained. When the status of the transitional circulation needs monitoring, both preductal (in the right hand) and post-ductal probes should be applied. A BP cuff is mandatory. A precordial stethoscope is a cheap and minimally invasive method to monitor hypovolaemia by the muffling of heart sounds. If an arterial line is placed, adequate distal perfusion should be ensured. The temperature probes are placed in the oesophagus or rectum, and over the skin.

Drug preparation

A saline flush should be drawn up to flush IV lines and drugs. The doses of induction agent, narcotic and muscle relaxant should be precalculated before the infant arrives in the OR. It is good practice to

Figure 4: Intubating a preterm infant using C-Mac videolaryngoscope

keep the 'stock' syringes well out of the way so that 1 mL and 2 mL syringes containing the appropriate amount of drugs are available, and overdosing can be avoided. The fluid volumes given with drugs should be recorded. The doses should be double-checked, especially neuraxial drugs and opioids. The emergency drugs should be drawn up in appropriate doses and concentration. These include atropine (20 μg/kg), suxamethonium (1–2 mg/kg) and adrenaline (10 μg/kg, i.e., 0.1 mL/kg of 1:10,000 adrenaline).

Induction

In the absence of IV access, sevoflurane is the inhalational agent of choice in neonates, due to the absence of airway irritation and relative cardiostability. It should be remembered that the high cardiac output combined with rapid respiratory rate makes for a rapid induction. Enhanced alveolar ventilation facilitates inhalational agent uptake. The minimum alveolar concentration (MAC) is reduced in preterms and peaks at 1–6 months.[11] Sevoflurane upward of 6% can cause apnoea in the neonate. The term/preterm infant may need assistance during induction, and the inhalational agent concentration should be kept at a lower range (e.g., sevoflurane 2%–3%). The immature myocardium is exquisitely sensitive to the depressant effects of volatile anaesthetic agents. Atropine premedication (20 μg/kg) is advisable to counter bradycardia at induction.

If IV access is present, ketamine 2 mg/kg or thiopentone 3–4 mg/kg may be administered, keeping in mind that the neonate may become apnoeic, and the practitioner should be facile at maintaining the airway. Rapid sequence intubation (RSI) is controversial in small babies and rarely used. Propofol is occasionally used in term babies. Tracheal intubation is usually carried out after administering atracurium (and fentanyl/sufentanil), which makes for a smooth and atraumatic intubation.[29] Smearing the laryngeal inlet and epiglottis with lignocaine gel using the operator's little finger may facilitate an 'awake look' or awake intubation in infants where there is a concern for securing the airway, for example, in syndromic infants. The choice of appropriate tube size is provided in Table 1.

The tube should be securely taped and note made of the depth of insertion in case it needs to be changed at any time in the perioperative period.

With the availability of paediatric size supraglottic devices, these are now being routinely used for airway management especially during ophthalmologic procedures for ROP.[30,31] Both sevoflurane and desflurane are useful volatile agents for maintenance of anaesthesia.[32,33]

Fluid therapy

The prepared fluid lines should be meticulously de-aired. The normal rates of infusion for a preterm are 100 mL/kg/24 h (4–5 mL/kg/h) and should contain dextrose. Operative losses should be replaced with lactated Ringer's or Plasmalyte (i.e., isotonic solutions).[34]

The recommended estimates for replacement are 1–2 mL/kg/h for superficial surgery, 4–7 mL/kg/h for thoracotomy and 5–10 mL/kg/h for abdominal surgery (from the APA consensus Guidelines on Perioperative Fluids Management in Children, 2007).[35] It is important to prevent both hyperglycaemia and hypoglycaemia[36] as both have disastrous consequences. The fluids may need to be restricted to reduce oedema in gastroschisis.[37]

Third-space losses are often difficult to estimate. Tachycardia, diminished heart sounds, hypotension, increased core-peripheral temperature gradient and delayed capillary refill should alert the anaesthesiologist for hypovolemia. Although good urine output is very reassuring, small volumes (0.5–2 mL/kg/h) may be difficult to measure. The position of the dicrotic notch on an arterial trace, pulse pressure variation and area under the arterial trace may be used as approximates of fluid volume and perfusion.

Spinal anaesthesia in the neonate and preterm infants

There has been a revival of interest in spinal anaesthesia[38-40] since the survival rate of extremely pre-term infants has increased. A significant number (11-40%) of ex-premature infants, develop inguinal hernia and other surgical conditions which can be managed by spinal anaesthesia [Table 5].[41,42] General anaesthesia (GA) has been associated with high incidence of postoperative apnoea, bradycardia, desaturation and requirement of prolonged post

Table 5: Indications for spinal anaesthesia

Inguinal hernia (55%)
Emergent surgery for duodenal atresia, anorectal malformations
PDA closure
Gastroschisis, omphalocele
Colostomy
Analgesia after cardiac surgery

operative mechanical ventilation in premature infants undergoing hernia repair,[42-46] which may be significantly low with spinal anaesthesia.[47]

Anatomy

The preterm and neonatal spines have one primary anterior concave curvature, and the lumbar and cervical lordosis are absent.[48] This 'straight' spine predisposes the neonate and preterm infant to high spinal blockade with small changes in position, for example, lifting the feet up to place the diathermy earthing pad.

The spinal cord ends between *L2 and L3* vertebrae in 90% of premature infants and between *L1 and L2* vertebrae in 92% of term infants. The dural sac is at the S4 level at birth and reaches the S2 level by the end of the first year [Figure 5]. The intercristal line crosses at the L5–S1 interspace at birth and the L5 vertebra in young children and is a safe landmark to prevent cord injury.[48]

The neonate may be kept in the lateral decubitus or sitting position [Figure 6]. The sitting position provides better view of the landmarks and increases CSF pressure. It is important to keep the head extended to prevent airway obstruction. A 45^0 head-up tilt has also been reported to result in better success and fewer bloody taps especially in infants.[48,49] Effect of the block can be judged by lack of response to pinch/tetanic stimulus. Absence of hip flexion indicates a block of L1.

Drugs and doses

Infant dose of bupivacaine for inguinal hernia repair is *0.6–1 mg/kg*, which is roughly two to three times the adult requirement (0.17–0.2 mg/kg). This is because of the larger volume of circulation (CSF volume in infants is 4 mL/kg, double that of the adult) and rapid drug clearance (high heart rate and cardiac output result in greater flow and turnover).

The various drugs used are hyperbaric bupivacaine (0.75% bupivacaine with 8.75% dextrose at 0.6 mg/kg), isobaric bupivacaine (0.8 mg/kg) with or without epinephrine and 1% tetracaine with 10% dextrose (in equal volume) with the addition of 0.02 mL of 1:1000 epinephrine.[48] Levobupivacaine and ropivacaine are 30%–40% less potent at the ED_{50} values of bupivacaine. The addition of hyperbaric dextrose increases the success rate and prolongs the duration of the block. Other additives that prolong the duration of action are epinephrine (1:200,000), clonidine (1 μg/kg), fentanyl (0.25–1 μg/kg) and neostigmine (1 μg/kg). Clonidine and fentanyl may result in sedation and respiratory depression necessitating bag-mask ventilation or intubation.

The distance from skin to epidural space is about 6 mm at birth, increasing to 10–12 mm at 1 year. It has also been estimated at 1 mm/kg. Paediatric spinal needles range from 22 to 29 G. Quincke, Sprotte and Whitacre variations are available. It is recommended to use styletted needles to avoid introduction of the epidermal tissue into the spinal canal leading to formation of epidermoid tumors.[48] The effect of the block can be judged by the lack of response to pinch/tetanic stimulus. The absence of hip flexion indicates a block of L1.

Adverse effects of spinal anaesthesia

Haemodynamic depression is uncommon.[50] Reported adverse sequelae include failure, inadvertent high blockade due to the change in position and respiratory depression consequent to the addition of clonidine/

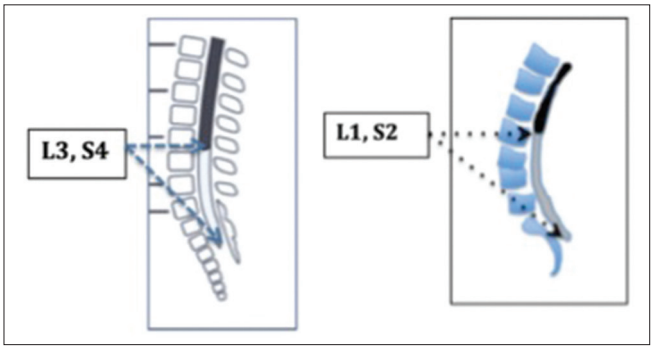

Figure 5: Preterm/neonate spine: cord ends L3, dural sac ends at S4; Spine at 1 year: cord ends at L1, dural sac ends at S2

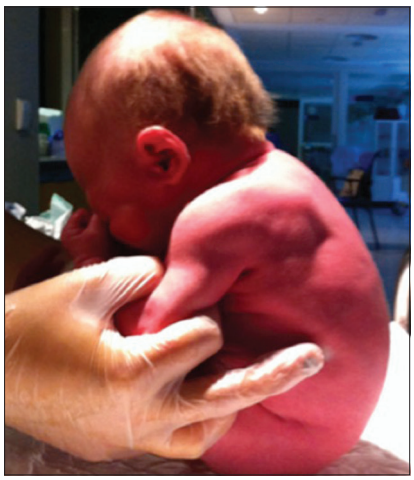

Figure 6: Infant held in sitting position for spinal anaesthesia

fentanyl or IV sedative supplementation. The presence of BPD and leukomalacia may result in apnoea/delayed discharge;[51] some series report significant failures.[52]

The GAS study cohort was also analyzed for failure rates of RA. This analysis noted that RA was sufficient for surgery in more than 80% of cases, spinal having a higher success rate compared with combined spinal–caudal technique.[53] A bloody tap was associated with block failure.

The 'GAS' (GA versus spinal) study

This was a multi-center RCT comparing regional vs. GA for effects on neurodevelopmental outcome and apnoea at 12 hours in 780 premature and ex-premature infants undergoing hernia repair.[3] Although less than 1 h of sevoflurane anaesthesia did not increase the risk of adverse neurodevelopmental outcome at 2 years and at 5 years of age compared with awake-regional anaesthesia, regional anaesthesia was associated with less hypotension than sevoflurane and less early apnoea.[54,55]

Summary

The steady increase in survivors of premature birth has led to an increase in such infants presenting for surgery. The immature cardiovascular system, the predisposition of the respiratory system to BPD and apnoea, and airway issues such as tracheomalacia and stenosis in these small infants call for expertise in management. Neuraxial blocks in preterms and neonates are well-established. Airway management is now easier due to the availability of appropriate size videolaryngoscopes. The effect of GA on the developing brain is still the subject of research, although preliminary reports indicate no neurodevelopmental adverse effect of sevoflurane used for 1–2 h.

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Conflicts of interest

There are no conflicts of interest.

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