Special considerations in the premature and ex-premature infant

Geoff Frawley

Abstract

Ex-premature infants and children are a heterogenous population, ranging from healthy children born at 36 weeks' gestation to formerly extremely premature children with significant medical issues that affect anaesthetic care. Preterm birth is associated with perinatal mortality, neurological disability (including cerebral palsy), severe morbidity in the first weeks of life, prolonged hospital stay after birth, readmission to hospital in the first year of life and increased risk of chronic lung disease.

Around 3% of newborns have a major congenital physical anomaly with 60% of congenital anomalies affecting the brain or heart and around 1% having multiple anomalies. Individual congenital conditions requiring surgical intervention in the neonatal period are rare. Gastroschisis is one of the most common abnormalities and has an incidence of around 1 in 2500 live births. Outside of the neonatal period, the most common surgical procedures performed in ex-premature infants are inguinal hernia repair and ophthalmologic procedures for underlying retinopathy of prematurity. After even minor surgical procedures, ex-premature infants are at higher risk for postoperative complications than infants born at term.

Keywords Apnoea; bronchopulmonary dysplasia; premature infant; spinal anaesthesia

Royal College of Anaesthetists CPD Matrix: 2D02, 2G01

Learning objectives

After reading this article, you should be able to:

- define the terms prematurity, extreme prematurity and post-menstrual age
- list the consequences of prematurity
- explain the basic principles of anaesthetizing a premature infant

Definitions

The American Academy of Pediatrics defines gestational age (GA) as time elapsed between the first day of the last menstrual period and the day of delivery; chronological age (CA) as time elapsed from birth and postmenstrual age (PMA) as GA plus CA. These definitions replace older definitions such as post-conception age (PCA). The World Health Organization (WHO) further defines preterm birth (birth <37 weeks), extremely preterm (<28 weeks); very preterm (28 to <32 weeks); and moderate to late preterm (32–37 weeks). In 2010 8.3% of babies were born preterm with most of these births occurring at a gestational age of 32–36 completed weeks. Preterm infants are also classified by birth weight as low birth weight (LBW <2500 g), very low birth weight (VLBW <1500 g) or extremely low birth weight (ELBW <1000 g).

Geoff Frawley *MBBS, FANZCA is a Consultant Paediatric Anaesthetist at Royal Children's Hospital, Melbourne, Australia and a Clinical Associate Professor, Department of Paediatrics, Melbourne University, Australia. Conflicts of interest: none declared.*

Consequences of prematurity

Mortality and morbidity

Perinatal mortality is inversely proportional to gestational age with the highest rates near the limit of viability (Table 1). In a population-based British study (EPICure 2 study), the survival and morbidity of 3378 extremely preterm infants (22–26 weeks) born in 2006 were reported. The live birth rate was 60% with 83% requiring admission to an intensive care unit (ICU) and active resuscitation was withheld in 9%. The survival to discharge for all live births was 51%, and the survival for infants admitted to ICU was 62%. Among the infants who survived to discharge major morbidities occurred in 59% including bronchopulmonary dysplasia (68%), abnormal cerebral ultrasound (13%), laser treatment for retinopathy of prematurity (ROP) (16%) and laparotomy for necrotizing enterocolitis (NEC) (8%). No major morbidity was reported in 41% of survivors to discharge.

Chronic lung disease

Bronchopulmonary dysplasia (BPD) is a chronic lung disease that remains one of the most prevalent long-term sequelae of premature birth. For Infants born less 32 weeks BPD requiring oxygen at 28 days of age BPD is defined as severe if an FiO_2 greater than 0.3 is required at 36 weeks PMA. Most infants currently developing BPD are born between 24 and 28 weeks' gestational age, during the time of canalicular and saccular development. BPD in the post-surfactant use era ('New' BPD) is characterized by uniform arrest of lung development, with simplified alveolar structures and dysmorphic capillaries. The severity of BPD is related to ventilator-induced barotrauma or volutrauma, oxygen toxicity, persistent patent ductus arteriosus and other unknown variables. New neonatal ventilator strategies such as high-frequency ventilation (HFOV) and nasal continuous positive airway pressure (CPAP) may reduce the incidence. Essentially BPD patients have a lifelong susceptibility to respiratory complications of anaesthesia. BPD is associated with bronchial hyper-reactivity and these infants have an increased risk of perioperative bronchospasm and oxygen desaturation. BPD also renders the pulmonary capillary network vulnerable to pulmonary vasoconstriction in response to perioperative stimuli such as hypothermia and pain.

Neurological injury

Ex-premature infants and children, especially those with severe neonatal brain injury, are more likely than term infants and children to have neurodevelopmental disabilities, including impaired cognitive skills, motor deficits and cerebral palsy, vision and hearing loss, and behavioural and psychological problems. The risk of these impairments increases with decreasing GA.

Please cite this article in press as: Frawley G, Special considerations in the premature and ex-premature infant, Anaesthesia and intensive care medicine (2016), http://dx.doi.org/10.1016/j.mpaic.2016.11.001

Morbidity and mortality of premature infants. Low-birth-weight infants are not necessarily low gestation and may have suffered intrauterine growth retardation

		Overall	Late preterm	Very preterm	Very low birth weight (VLBW)	Extremely low birth weight (ELBW)
Definition	Completed weeks' gestation	<37 weeks	32–36 weeks	28–31 weeks	<1500 g	<1000 g
Incidence	% Live births	7.5%	6%	0.7%	1%	0.5%
Perinatal mortality	Mortality rate per live birth	2:1000	7.2:1000	36:1000	40:1000	125:1000
Neurological injury	IVH	2–5%			20%	45%
	Cerebral palsy	1.9:1000	1:1000	33:1000	60:1000	74:1000
	Blindness	0.1%		3%		
	Deafness	0.1%		2%		
Chronic lung disease	Mod severe BPD			12%	20%	30%
	Home oxygen	0.3:1000		10%	4%	
Congenital heart disease		8:1000	1.3%		4.4%	8.5%
Necrotizing enterocolitis		3.8:1000			5–10%	

IVH, intraventricular haemorrhage; BPD, bronchopulmonary dysplasia. For infants less than 1500 g the incidences of mild, moderate and severe BPD were 13.5, 4.8 and 2.6% respectively.

Table 1

Cardiac abnormalities

There is a higher prevalence of cardiovascular malformations among infants born prematurely (12.5 cases per 1000 preterm infants vs 5.1 cases per 1000 full-term infants). The most common defects are pulmonary atresia with ventricular septal defect (23%); complete atrioventricular septal defect (22%); and coarctation of the aorta, tetralogy of Fallot, and pulmonary valve stenosis (each 20%).

Retinopathy of prematurity

ROP is a developmental vascular proliferative disorder that occurs in the retina of preterm infants with incomplete retinal vascularization. The most important risk factor for developing ROP is prematurity but more than 50 separate risk factors have been identified including elevated arterial oxygen tension. ROP typically begins at about 34 weeks PMA, but may be seen as early as 30–32 weeks. It advances irregularly until 40–45 weeks PMA, but resolves spontaneously in the majority of infants. ROP screening is recommended in all infants with a birth weight of 1500 g or less, or a GA of less than 30 weeks.

Laryngotracheal abnormalities

Infants who require prolonged intubation can develop subglottic stenosis or tracheomalacia. Airway obstruction may occur during induction of anaesthesia, and a smaller-diameter endotracheal tube may be needed. Infants who have had a procedure to relieve airway obstruction may be at risk for chronic airway difficulty and increased risk of aspiration related to limited motion and decreased sensation of supraglottic tissue. The rate of aspiration may be 6%, with the highest incidence occurring in the former extremely preterm infant (<28 weeks GA).

Anaesthesia

General principles

All neonatal anaesthesia should occur in centres appropriate for ongoing management (NHS directive E02/S/c 2013/14 Paediatric Surgery: Neonates). The general principles include appropriate airway management, reliable intravascular access, maintenance of temperature and metabolic homeostasis and adequate analgesia. Most anaesthetic agents require modification to dose and duration when used in infants (Table 2). Weiss has introduced the concept of the 10-N quality paediatric anaesthetic where paediatric anaesthesia includes avoidance of fear and pain, maintenance of homeostasis, normotension, normal heart rate, normovolaemia, normoxaemia, normocarbia, normal electrolytes, normoglycaemia and normothermia. There is a however a lack of normative data describing optimal intraoperative anaesthetized blood pressure. In premature infants a common rule is that the mean arterial pressure (MAP) should not be less than the child's postconception age in weeks. A recent report suggests an MAP of more than 35 mmHg in anaesthetized neonates and infants under 6 months preserves cerebral oxygenation measured by near infrared spectroscopy (NIRS). The optimal intraoperative FiO_2 and PaO_2 are also ill defined. Two randomized controlled trials of supplemental oxygen for infants with chronic neonatal lung disease support a target saturation of 91–95%. The BOOST trial and the Supplemental Therapeutic Oxygen for Pre-threshold Retinopathy of Prematurity (STOP-ROP) trial suggest that infants in the higher Sp_{O2} range had a greater incidence of chest infections suggesting that even low-flow nasally delivered oxygen may be toxic to respiratory epithelium.

Perioperative morbidity: the incidence of perioperative morbidity is increased in ex-premature infants with the most frequent events being upper airway obstruction, laryngospasm, apnoea and post-intubation stridor. The initial perioperative cardiac arrest registry (POCA) data suggest that the incidence of cardiac arrest in ex-premature infants was much higher than older children. The principal factor involved was drug related, especially halothane-induced bradycardia. The most recent POCA data suggest the primary causes are now non-cardiac surgery in infants with congenital cardiac disease. Two European Society of Anaesthesiology prospective multicentre observational studies aiming to describe perioperative risk in children (The APRICOT trial) and neonates (the NECTARINE trial) are due to report their findings in late 2016.

Please cite this article in press as: Frawley G, Special considerations in the premature and ex-premature infant, Anaesthesia and intensive care medicine (2016), http://dx.doi.org/10.1016/j.mpaic.2016.11.001