ODERN technology and expert nursing care have made important contributions to improving the health and overall survival of high risk infants. However, infants who are born considerably before term and survive are particularly susceptible to the development of sequelae related to their preterm birth. These conditions, which also can occur in term and near-term infants, but not so frequently, include necrotizing enterocolitis, bronchopulmonary dysplasia (BPD), intraventricular and periventricular hemorrhage, and retinopathy of prematurity (ROP). The focus of this chapter is on care of the preterm infant. Care of other high risk infants with gestational age–related problems also is discussed.

PRETERM INFANTS

Preterm infants are at risk because their organ systems are immature and they lack adequate reserves of bodily nutrients. The potential problems and care needs of the preterm infant weighing 2000 g differ from those of the term, post-term, or postmature infant of equal weight. If these infants have physiologic disorders and anomalies as well, these affect the infant’s response to treatment. In general, the closer infants are to term from the standpoint of both gestational age and birth weight, the easier their adjustment to the external environment. The cost of the care required by low-birth-weight (LBW) infants is estimated to be in the billions of dollars each year and is increasing as the use of technology increases.

Varying opinions exist about the practical and ethical dimensions of resuscitation of extremely low-birth-weight infants (those infants whose birth weight is 1000 g or less). Ethical issues associated with resuscitation that nurses caring for such infants are confronted with include the following:

- Should resuscitation be attempted?
- Who should decide?
- Is the cost of resuscitation justified?
- Do the benefits of technology outweigh the burdens in relation to the quality of life?
All people involved (health care providers, parents, ethicists, clergy, attorneys) should participate in the discussions in which these controversial issues are addressed.

**CARE MANAGEMENT**

**Assessment and Nursing Diagnoses**

For the high risk infant, an accurate assessment of gestational age (see Chapter 26) is critical in helping the nurse identify the potential problems the newborn is likely to have. The response of the preterm or postterm infant to extrauterine life is different from that of the term infant. By understanding the physiologic basis of these differences, the nurse can assess these infants, determine the response of the preterm or postterm infant, and discern which potential problems are most likely to occur.

**Physiologic Functions**

**Respiratory Function.** The preterm infant is likely to have difficulty making the pulmonary transition from intrauterine to extrauterine life. Numerous problems may affect the respiratory systems of preterm infants and may include the following:

- Decreased number of functional alveoli
- Deficient surfactant levels
- Smaller lumen in the respiratory system
- Greater collapsibility or obstruction of respiratory passages
- Insufficient calcification of the bony thorax
- Weak or absent gag reflex
- Immature and friable capillaries in the lungs
- Greater distance between functional alveoli and the capillary bed

In combination, these deficits severely hinder the infant’s respiratory efforts and can produce respiratory distress or apnea.

Respiratory difficulty often follows a progressive pattern. Infants normally breathe between 30 and 60 breaths/min, relying significantly on their abdominal muscles to accomplish this. However, the respiratory rate may increase without a change in rhythm. Early signs of respiratory distress include flaring of the nares and an expiratory grunt. Depending on the cause, retractions may begin as substernal, suprasternal, or clavicular retractions (Fig. 40-1). If the infant shows increasing respiratory effort—for example, seesaw breathing patterns, retractions, flaring of the nares, expiratory grunts, and/or apneic spells (Fig. 40-2)—this indicates deepening distress. A compromised infant’s color progresses from pink to circumoral cyanosis and then to generalized cyanosis. Acrocyanosis deepens. (Acrocyanosis is a normal finding in the neonate, but central cyanosis indicates the existence of an underlying problem.)

Periodic breathing is a respiratory pattern commonly seen in preterm infants. Such infants exhibit 5- to 10-second respiratory pauses followed by 10 to 15 seconds of compensatory rapid respirations. Such periodic breathing should not be confused with apnea, which is a 15- to 20-second cessation of respiration. The nurse must be prepared to provide oxygen and ventilation as necessary.

**Cardiovascular Function.** Evaluation of heart rate and rhythm, skin color, blood pressure, perfusion, pulses, oxygen saturation, and acid-base status provides information on the cardiovascular status. The nurse must be prepared to intervene if symptoms of hypovolemia or shock, or both, are found. These symptoms include hypotension, slow capillary refill (longer than 3 seconds), and continued respiratory distress despite the provision of oxygen and ventilation.

An accurate and timely blood pressure reading can assist in making an early diagnosis of cardiorespiratory disease and in monitoring the effects of fluid therapy. Blood pressure readings can be obtained by the Doppler method or by an electronic monitor.

**Maintaining Body Temperature.** Preterm infants are susceptible to temperature instability as a result of numerous factors. Preterm infants are at high risk for heat loss because of their large body surface area in relation to weight. Other factors that place preterm infants at risk for temperature instability include the following:

- Minimal insulating subcutaneous fat
- Limited stores of brown fat (an internal source for the generation of heat present in normal term infants)
- Fragile capillaries
- Decreased or absent reflex control of skin capillaries (shiver response)
- Inadequate muscle mass activity (rendering the preterm infant unable to produce its own heat)
- Poor muscle tone resulting in more body surface area being exposed to the cooling effects of the environment
- An immature temperature regulation center in the brain

The goal of thermoregulation is to create a neutral thermal environment (NTE), which is the environmental temperature at which oxygen consumption is minimal.
but adequate to maintain the body temperature (Kenner, 2003). Armed with the knowledge of the four mechanisms of heat transfer (convection, conduction, radiation, and evaporation), the nurse can then create an environment for the preterm infant that prevents temperature instability (see Chapter 25). The infant will be kept in a radiant warmer or isolette with control settings at a temperature to maintain the NTE. Because the preterm infant has few reserves (extra energy calories, minimal or no fat stores), cold sensitivity is a problem. This infant can easily lose heat and experience stress from the cold. Physiologically the infant tries to conserve heat and burns more calories, and the metabolic system goes into overdrive, further stressing the already compromised neonate. There is mounting evidence to support the need for maintaining a watchful eye on increases in external heat sources as preterm infants’ rectal and nasopharyngeal temperatures change more than might be expected (Simbruner, Ruttnr, Schulze, & Perzlmaier, 2005). The nurse’s role is to prevent or minimize cold stress by recognizing the risk factors and using intervention strategies to prevent and treat such stress. Signs of cold stress are listed in Box 40-1. Overheating can also lead to apnea, tachycardia, and eventually bradycardia, as well as consumption of calories that the preterm infant cannot afford to expend (Simbruner et al.).

**Central Nervous System Function.** The preterm infant’s central nervous system (CNS) is susceptible to injury as a result of the following problems:

- Birth trauma that includes damage to immature structures
- Bleeding from fragile capillaries
- An impaired coagulation process, including prolonged prothrombin time
- Recurrent anoxic episodes
- Predisposition to hypoglycemia

---

**FIG. 40-2 Observation of retractions. Silverman-Anderson index of respiratory distress is determined by grading each of five arbitrary criteria: grade 0, no respiratory difficulty; grade 1, moderate difficulty; grade 2, maximum difficulty. The retraction score is a sum of these values; a total score of 0 indicates no dyspnea, whereas a total score of 10 indicates maximal respiratory distress. (Modified from Silverman, W., & Anderson, D. [1956]. A controlled clinical trial of effects of water mist on obstructive respiratory signs, death rate and necropsy findings among premature infants. *Pediatrics*, 17[1], 1-10.)**

**Box 40-1 Signs of Cold Stress**

<table>
<thead>
<tr>
<th>Sign</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Skin temperature</td>
<td>Decreases before other signs</td>
</tr>
<tr>
<td>Respiratory rate</td>
<td>Initially increases, then apneic spells occur</td>
</tr>
<tr>
<td>Heart rate</td>
<td>Initially increases, then bradycardia occurs</td>
</tr>
<tr>
<td>Skin color</td>
<td>Mottled with acrocyanosis increasing to cyanosis</td>
</tr>
<tr>
<td>Physical activity</td>
<td>Increased in term infants without respiratory distress</td>
</tr>
<tr>
<td>Thermoregulatory control</td>
<td>Decreased in term infants with respiratory distress</td>
</tr>
<tr>
<td></td>
<td>Decreased in premature infants</td>
</tr>
</tbody>
</table>
Research evidence indicates that the developing nervous system has the ability to reorganize neural connection after injury, meaning that some injuries that would be permanent in adults are not so in infants. Certain neurologic signs appear to be predictive of later neurologic abnormalities. These signs include hypotonia, a decreased level of activity, weak cry for more than 24 hours, and an inability to coordinate suck and swallow. Ongoing assessment and documentation of these neurologic signs is needed for the purpose of discharge teaching and making follow-up recommendations, as well as for their predictive value.

A new area of research is “brain nurturing.” This refers to examination of brain development as related to postnatal experiences including child care and education (Ito, 2004). Linkages are sought between brain development and long-term conditions such as attention deficit disorder and learning disabilities. The thought is that the brain can be nurtured toward more positive developmental outcomes if these linkages exist.

**Maintaining Adequate Nutrition.** The goal of neonatal nutrition is to promote normal growth and development. However, the maintenance of adequate nutrition in the preterm infant is complicated by problems with intake and metabolism. The preterm infant has the following disadvantages with regard to intake: weak or absent suck, swallow, and gag reflexes; a small stomach capacity; and weak abdominal muscles. The preterm infant’s metabolic functions are compromised by a limited store of nutrients, a decreased ability to digest proteins or absorb nutrients, and immature enzyme systems.

The nurse must continuously assess the infant’s ability to take in and digest nutrients. Some preterm infants require gavage or intravenous (IV) feedings instead of oral feedings. An area of research that holds promise for preterm infants is use of minimal enteral nutrition (MEN) that may only be 1 ml/hr (Hawthorne, Griffin, & Abrams, 2004; Tyson & Kennedy, 2002). These feedings stimulate the gastrointestinal system with minute amounts of formula or breast milk, usually given via gavage, so that when enteral feedings can really begin, the gastrointestinal system is primed for nutrient absorption.

**Maintaining Renal Function.** The preterm infant’s immature renal system is unable to (1) adequately excrete metabolites and drugs; (2) concentrate urine; or (3) maintain acid-base, fluid, or electrolyte balance. Therefore intake and output, as well as specific gravity, must be assessed. Laboratory tests must be done to assess acid-base and electrolyte balance. Medication levels also are monitored in preterm infants because certain medications can overwhelm the immature system’s ability to excrete them.

**Maintaining Hematologic Status.** The preterm infant also is particularly predisposed to hematologic problems because of the following problems:
- Increased capillary fragility
- Increased tendency to bleed (prolonged prothrombin time and partial thromboplastin time)
- Slowed production of red blood cells resulting from rapid decrease in erythropoiesis after birth
- Loss of blood due to frequent blood sampling for laboratory tests
- Decreased red blood cell survival related to the relatively larger size of the red blood cell and its increased permeability to sodium and potassium

The nurse assesses such infants for any evidence of bleeding from puncture sites and the gastrointestinal (GI) tract. Infants also are examined for signs of anemia (decreased hemoglobin and hematocrit levels, pale skin, increased apnea, lethargy, tachycardia, and poor weight gain). Amount of blood drawn is recorded.

**Resisting Infection.** Preterm infants are at increased risk for infection because they have a shortage of stored maternal immunoglobulins, an impaired ability to make antibodies, and a compromised integumentary system (thin skin and fragile capillaries). Preterm infants exhibit various nonspecific signs and symptoms of infection (Box 40-2). Early identification and treatment of sepsis are essential (see Chapter 38). As with all aspects of care, strict attention to handwashing is the single most important measure to prevent iatrogenic infections.

**Growth and Development Potential**

Although it is impossible to predict with complete accuracy the growth and development potential of each preterm infant, some findings support an anticipated favorable outcome in the absence of ongoing medical sequelae that can affect growth, such as BPD, necrotizing enterocolitis, and CNS problems. The lower the birth weight, the greater the likelihood for negative sequelae. The growth

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**Box 40-2 Signs and Symptoms of Infection**

<table>
<thead>
<tr>
<th>Temperature instability</th>
<th>Hyperthermia</th>
</tr>
</thead>
<tbody>
<tr>
<td>Central nervous system changes</td>
<td>Lethargy</td>
</tr>
<tr>
<td>Changes in color</td>
<td>Irritability</td>
</tr>
<tr>
<td>Cardiovascular instability</td>
<td>Poor perfusion</td>
</tr>
<tr>
<td>Jaundice</td>
<td>Hypotension</td>
</tr>
<tr>
<td>Bradycardia/tachycardia</td>
<td>Respiratory distress</td>
</tr>
<tr>
<td>Tachypnea</td>
<td>Apnea</td>
</tr>
<tr>
<td>Retractions, nasal flaring, grunting</td>
<td>Gastrointestinal problems</td>
</tr>
<tr>
<td>Vomiting</td>
<td>Feeding intolerance</td>
</tr>
<tr>
<td>Diarrhea</td>
<td>Glucose instability</td>
</tr>
<tr>
<td>Metabolic acidosis</td>
<td></td>
</tr>
</tbody>
</table>
and development milestones (e.g., motor milestones, vocalization, growth) are corrected for gestational age until the child is approximately 2½ years old.

The age of a preterm newborn is corrected by adding the gestational age and the postnatal age. For example, an infant born at 32 weeks of gestation 4 weeks ago would now be considered 36 weeks of age. The infant’s corrected age at 6 months after the birth date is then 4 months, and the infant’s responses are accordingly evaluated against the norm expected for a 4-month-old infant.

Certain measurable factors predict normal growth and development. The preterm infant experiences catch-up body growth during the first 2 years of life; this is most likely to occur when the infant has a normal birth length (Kliegman, 2006). The head is the first to experience catch-up growth, followed by a gain in weight and height. At the infant’s discharge from the hospital, which usually occurs between 37 and 40 weeks of postconceptional age, the infant should exhibit the following characteristics:

- An ability to raise the head when prone and to hold the head parallel with the body when tested for the head-lag response
- An ability to cry with vigor when hungry
- An appropriate amount and pattern of weight gain according to a growth grid
- Neurologic responses appropriate for corrected age

At 39 to 40 weeks of corrected age, the infant should be able to focus on the examiner’s or parent’s face and to follow with his or her eyes.

Of very low-birth-weight (VLBW) (<1500 g) survivors, approximately 15% to 25% will have neurologic and/or cognitive disabilities in varying degrees of severity (Wilson-Costello & Hack, 2006). Research is focused on examining other factors including environmental ones that may cause adverse cognitive and neurodevelopmental outcomes for VLBW and extremely low-birth-weight (ELBW) babies by the time they reach infancy or school age (Vohr et al., 2005).

### Parental Adaptation to Preterm Infant

The experience of parents whose infant is born prematurely or is otherwise high risk is different from the experience of parents whose infant is born at term and is normal (Davis & Stein, 2004; Holditch-Davis, Cox, Miles, & Belyea, 2003; Swartz, 2005). This may cause parental attachment and the adaptation to the parental role to differ as well.

#### Parental Tasks.

Parents of preterm infants must accomplish numerous psychologic tasks before effective relationships and parenting patterns can evolve. These tasks include the following:

- Experiencing **anticipatory grief** over the potential loss of an infant. The parent grieves in preparation for the infant’s possible death, although the parent clings to the hope that the infant will survive. This process begins during labor and lasts until the infant dies or shows evidence of surviving. Anticipatory grief occurs when families have knowledge of an impending loss, such as when a baby is admitted to a neonatal intensive care unit (NICU) with problems or when a diagnosis of an anencephalic fetus is made with ultrasonography. The baby is still alive, but the prognosis is poor. Being able to anticipate the loss gives families an opportunity to plan, feel more in control of their situation, and say good-bye in a special way. However, some individuals or family members may distance or detach themselves from the experience or from their loved ones as a way of protecting themselves from the pain of loss and grief.

#### Parental Responses.

Parents progress in interactions with their infants from maintaining an **en face** position, stroking, and touching their infant (Fig. 40-3 and Fig. 40-4) to assuming some infant activities, such as feeding, bathing, and changing the infant. Parents go through numerous phases of adjustment as they learn to parent their infant. Nurses assist the transition to parenthood through their teaching and support of parental efforts.

### Parenting Disorders.

The incidence of physical and emotional abuse has been found to be greater in infants who, because of preterm birth or illness, are separated from their parents for a time after birth. Physical abuse
includes varying degrees of poor nutrition, poor hygiene, and battering. Emotional abuse ranges from subtle disinterest to outright dislike of the infant to abandonment. Shaken baby syndrome is another possibility with preterm infants. This problem occurs when the child is shaken so violently that brain damage and retinal hemorrhages occur.

**NURSE ALERT**
Parents may show preferential treatment toward the brothers and sisters of the infant, discipline the infant harshly for normal behaviors, have extremely high expectations of the infant, or show other types of overt or covert negative parental responses.

Factors surrounding the birth may predispose parents to treat their infant this way because subconsciously they have rejected the infant. These factors might include parental pain and anxiety, a heavy financial burden because of the cost of the infant’s care, unresolved anticipatory grief, a threat to self-esteem, or the fact that the infant was the product of an unwanted pregnancy. The goal of health professionals is to identify abuse and neglect early so that further problems can be prevented and, in turn, the incidence of such abuse can be reduced.

Potential nursing diagnoses for high risk infants and their parents include the following:

- Impaired gas exchange related to
  - decreased number of functional alveoli
  - deficiency of surfactant
- Ineffective breathing pattern related to
  - inadequate chest expansion, secondary to infant position
- Ineffective thermoregulation related to
  - immature thermoregulation center
- Risk for infection related to
  - invasive procedures
  - decreased immune response

**Expected Outcomes of Care**
The plan of nursing care for the preterm infant is directed by the physiologic needs of the infant’s immature systems and often involves emergency treatments and procedures. Nursing care is a critical element in determining the infant’s chances for survival, as well as normal development. In addition to meeting the infant’s physical needs, nursing care is planned in conjunction with parents to promote parent-infant attachment and interaction. Expected outcomes are presented in client-centered terms and include that the infant will do the following:

- Maintain physiologic functioning.
- Maintain adequate nutrition.
- Experience no or minimal hematologic problems.
- Remain free of infection.
- Develop no retinal problems.
• Have no trauma to the immature musculoskeletal system.
• Experience attachment to parents.
  Expected outcomes for the parents include that they will do the following:
• Perceive the infant as potentially normal (if this is medically substantiated).
• Provide care competently and comfortably.
• Experience pride and satisfaction in the care of their infant.
• Organize their time and energies to meet the love, attention, and care needs of the other members of the family, as well as their own needs.

Plan of Care and Interventions

The best environment for fetal growth and development is the uterus of a healthy, well-nourished woman. The goal of care for the preterm infant is to provide an extrauterine environment that approximates the healthy intrauterine environment to promote normal growth and development. Physicians, nurses, nurse practitioners, infant developmental specialists, and respiratory therapists work together as a team to provide the intensive care needed.

The admission of a preterm newborn to the intensive care nursery usually represents an emergency situation. Immediately after admission, a rapid initial evaluation is done to determine the infant’s need for lifesaving treatment. Resuscitation is started in the birthing unit, and the newborn’s need for warmth and oxygen is provided for during transfer to the nursery.

Nursing care is focused on the continuous assessment and analysis of the infant’s physiologic status. Nurses fulfill many roles in providing the intensive and extended care that these infants require. In addition, they are the support persons and teachers during the first phase of the parents’ adjustment to the birth of their preterm infant.

The nurse uses many technologic support systems to monitor the body responses and maintain the body functions of the infant. Technical skill must be combined with a gentle touch and concern about the traumatic effects of harsh lighting and the volume of machinery noise. The NICU environment may be a major contributing factor to learning and behavioral problems in preterm infants (Symington & Pinelli, 2003). Early interventions within the NICU can have a positive impact on neurobehavioral outcomes (Blauw-Hosper & Hadders-Algra, 2005).

Physical Care

The environmental support measures for the preterm infant typically consist of the following equipment and procedures:
• An incubator or radiant warmer placed over the infant to control body temperature (NTE)
• Oxygen administration, depending on the infant’s cardiopulmonary and circulatory status
• Electronic monitors as needed for the observation of respiratory and cardiac functions
• Assitive devices for positioning the infant in neutral flexion and with boundaries
• Clustering of care and minimization of stimulation according to infant cues
Various metabolic support measures that may be instituted consist of the following:
• Parenteral fluids to help support nutrition and maintain normal arterial blood gas (ABG) levels and acid-base balance
• IV access to facilitate the administration of antibiotic therapy if sepsis is a concern
• Blood work to monitor ABG levels, pH, blood glucose levels, electrolytes, and the status of blood cultures

Maintaining Body Temperature

The high risk infant is susceptible to heat loss and its complications. In addition, LBW infants may be unable to increase their metabolic rate because of impaired gas exchange, caloric intake restrictions, or poor thermoregulation. Transepidermal water loss is greater because of skin immaturity in very preterm infants (those at less than 28 weeks of gestation) and can contribute to temperature instability.

High risk infants are cared for in the thermoneutral environment created by use of an external heat source. A probe to an external heat source supplied by a radiant warmer or a servocontrolled incubator is attached to the infant. The infant acts as a thermostat to regulate the amount of heat supplied by the external source. This idealized environment maintains an infant’s normal body temperature between 36.5º C and 37.2º C. Maintaining a thermoneutral condition in the youngest, most immature infants decreases the need for them to generate additional heat. As a result, excessive oxygen consumption is prevented in such compromised infants (Blake & Murray, 2002).

Oxygen Therapy

Clinical criteria for identifying the need for oxygen administration include increased respiratory effort, respiratory distress with apnea, tachycardia, bradycardia, and central cyanosis with or without hypotonia. The need for oxygen should be substantiated by biochemical data (arterial oxygen pressure [PaO₂] of less than 60 mm Hg or an oxygen saturation of less than 92%). High risk infants often require saturations of more than 95% to maintain respiratory stability because their hemoglobin levels are frequently low. As the PaO₂ decreases, less oxygen is released from the hemoglobin, which increases the risk for cellular hypoxia.

Oxygen administered to an infant is warmed and humidified to prevent cold stress and drying of the respiratory mucosa. During the administration of oxygen, the concentration, volume, temperature, and humidity of the gas are carefully controlled. Delivery of oxygen for more than a few minutes requires the use of special equipment (hood, nasal cannula, positive-pressure mask, or endotracheal tube) because the concentration of free-flow oxygen cannot be monitored accurately. Free-flow oxygen into an
incubator should not be used because the concentration fluctuates dramatically each time the doors or portholes are opened. The indiscriminate use of oxygen may be hazardous. Possible complications of oxygen therapy include retinopathy of prematurity and BPD.

**NURSE ALERT**

Administration of a therapeutic level of oxygen for a severely depressed infant could cause significant physiologic harm if given to an infant with mild respiratory disease.

Infants who need oxygen should have their respiratory status assessed accurately every 1 to 2 hours; this includes a continuous pulse oximetry reading and at least one ABG measurement (Cifuentes, Segars, & Carlo, 2003). The interventions implemented are then determined on the basis of the findings yielded by the clinical assessment, including telemetry (pulse oximetry or tcPO₂ monitoring) and laboratory tests (Cifuentes et al.). The interventions ordered are those that can directly manage the underlying disease process and range from hood oxygen administration to ventilator therapy.

**Hood Therapy.** A hood can be used to administer oxygen to infants who do not require mechanical pressure support. The hood is a clear plastic cover that is sized to fit over the head and neck of the infant (Fig. 40-5, A). Inside the hood the infant receives the correct amount of oxygen. The nurse checks the oxygen level every 1 to 2 hours because the concentration must be adjusted in response to the infant’s condition.

**Nasal Cannula.** Infants requiring low-flow amounts of oxygen can benefit from the use of a nasal cannula (Fig. 40-5, B). These are of particular value for older infants who are recuperating but still require supplemental oxygen. They are the preferred method for home oxygen administration. They permit the infant to receive an adequate, continuous flow of oxygen while allowing optimal vision, positioning, and parental holding. Infants also can breastfeed while receiving oxygen by this method. However, the nasal prongs must be inspected frequently to make sure they are not partially obstructed by milk or secretions. Nasal cannulas allow easier feedings and psychosocial interactions.

**Continuous Positive Airway Pressure Therapy.** Infants who are unable to maintain an adequate PaO₂ despite the administration of oxygen by hood or nasal cannula may require the delivery of oxygen by using continuous positive airway pressure (CPAP). CPAP infuses oxygen or air under a preset pressure by means of nasal prongs, a face mask, or an endotracheal tube (Fig. 40-6, A). It is often

achieved by sending the oxygen bubbling through water to the infant; this is referred to as bubble CPAP. Research is investigating whether the work of neonatal breathing is improved with bubble CPAP versus variable-flow devices (Liptsen et al., 2005). In either case, an orogastric tube should be used for decompression of the stomach during use of nasal prongs. CPAP increases the functional residual capacity, improves the diffusion time of pulmonary gases, including oxygen, and can decrease pulmonary shunting. If implemented early enough, CPAP may preclude the need for mechanical ventilation (Cifuentes et al., 2003). CPAP can cause vascular shunting in the pulmonary beds, which can lead to persistent pulmonary hypertension and severe respiratory distress.

**Mechanical Ventilation.** Mechanical ventilation must be implemented if other methods of therapy cannot correct abnormalities in oxygenation (Fig. 40-6, B). Its use is indicated whenever blood gas values reveal the existence of severe hypoxemia or severe hypercapnia. The condition of the infant with apnea with bradycardia, ineffective respiratory effort, shock, asphyxia, infection, meconium aspiration syndrome, respiratory distress syndrome, or congenital defects that affect ventilation also may deteriorate and require intubation to reverse the process (Cifuentes et al., 2003). Dexamethasone may be administered to prevent chronic lung disease (Gross, Anbar, & Mettelman, 2005).

The ventilator settings are determined by the infant’s particular needs. The ventilator is set to provide a predetermined amount of oxygen to the infant during spontaneous respirations and also to provide mechanical ventilation in the absence of spontaneous respirations. Newer technologies in ventilation allow oxygen to be delivered at lower pressures and in assist modes, thereby preventing the overriding of the infant’s spontaneous breathing and providing distending pressures within a physiologic range. Barotrauma and associated complications such as pneumothorax (accumulation of air in the pleural space) and pulmonary interstitial emphysema (PIE) (free air that accumulates in interstitial tissue) are decreased. See Table 40-1 for an explanation of types of mechanical ventilation used in newborns.

**Surfactant Administration.** Surfactant can be administered as an adjunct to oxygen and ventilation therapy. Before 34 weeks of gestation, most infants do not produce enough surfactant to survive extrauterine life. As a result, lung compliance is decreased, and not enough gas exchange occurs as the lungs become atelectatic and require greater pressures to expand. With administration of artificial surfactant, respiratory compliance is improved until the infant can generate enough surfactant on his or her own. Exogenous surfactant is either artificial or natural and is given in several doses through an endotracheal tube.

### Table 40-1 Common Methods for Assisted Ventilation in Neonatal Respiratory Distress*

<table>
<thead>
<tr>
<th>METHOD</th>
<th>DESCRIPTION</th>
<th>HOW PROVIDED</th>
</tr>
</thead>
<tbody>
<tr>
<td>Continuous distending pressure—</td>
<td>Provides constant distending pressure to airway in spontaneously breathing</td>
<td>Nasal prongs Endotracheal tube Face mask Nasal cannula or nasopharyngeal tubes</td>
</tr>
<tr>
<td>continuous positive airway pressure</td>
<td>infant</td>
<td>Bubble CPAP uses water resistance Endotracheal intubation</td>
</tr>
<tr>
<td>(CPAP)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intermittent mandatory ventilation</td>
<td>Allows infant to breathe spontaneously at own rate but provides mechanical</td>
<td>Patient-triggered infant ventilator with signal detector and A/C mode;</td>
</tr>
<tr>
<td>(IMV)</td>
<td>cycled respirations and pressure at regular preset intervals; infant may</td>
<td>endotracheal tube; SIMV, A/C, and pressure support are also referred to as</td>
</tr>
<tr>
<td></td>
<td>maintain asynchronous ventilation efforts, which diminishes effective gas</td>
<td>patient-triggered ventilation</td>
</tr>
<tr>
<td></td>
<td>exchange; uses positive end-expiratory pressure (PEEP)</td>
<td></td>
</tr>
<tr>
<td>Synchronized intermittent</td>
<td>Mechanically delivered breaths are synchronized to the onset of spontaneous</td>
<td></td>
</tr>
<tr>
<td>mandatory ventilation (SIMV)</td>
<td>infant breaths; assist or control (A/C) mode facilitates full inspiratory</td>
<td></td>
</tr>
<tr>
<td></td>
<td>synchrony; involves signal detection of onset of spontaneous respiration</td>
<td></td>
</tr>
<tr>
<td></td>
<td>from abdominal movement, thoracic impedance, and airway pressure or flow</td>
<td></td>
</tr>
<tr>
<td></td>
<td>changes; pressure support ventilation provides an inspiratory pressure assist</td>
<td></td>
</tr>
<tr>
<td></td>
<td>when spontaneous breathing is detected to decrease infant’s work of</td>
<td></td>
</tr>
<tr>
<td></td>
<td>breathing</td>
<td></td>
</tr>
<tr>
<td>Volume guarantee ventilation</td>
<td>Delivers a predetermined volume of gas using an inspiratory pressure that</td>
<td>Volume guarantee ventilator with flow sensor; endotracheal tube</td>
</tr>
<tr>
<td>(HFO)</td>
<td>varies according to the infant’s lung compliance (often used in conjunction</td>
<td></td>
</tr>
<tr>
<td>High-frequency jet ventilation (HFJV)</td>
<td>with SIMV)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Application of high-frequency, low-volume, sine-wave flow oscillations to</td>
<td>Variable-speed piston pump (or loudspeaker, fluidic oscillator); endotracheal</td>
</tr>
<tr>
<td></td>
<td>airway at rates between 480 and 1200 breaths/min</td>
<td>tube</td>
</tr>
<tr>
<td></td>
<td>Uses a separate, parallel, low-compliant circuit and injector port to</td>
<td>May be used alone or with low-rate IMV; endotracheal tube</td>
</tr>
<tr>
<td></td>
<td>deliver small pulses or jets of fresh gas deep into airway at rates between</td>
<td></td>
</tr>
<tr>
<td></td>
<td>250 and 900 breaths/min</td>
<td></td>
</tr>
</tbody>
</table>

*This is not a comprehensive list of available ventilation modes. For more information, consult specific references on mechanical ventilation such as Donn, S., & Sinha, S. (2003). Invasive and noninvasive neonatal mechanical ventilation. *Respiratory Care*, 48(4), 426-441.*
Surfactant has reduced the morbidity and mortality in infants of less than 25 weeks of gestation (Hintz et al., 2005). As with any drug therapy, the infant must be monitored for the occurrence of potential side effects such as a patent ductus arteriosus (PDA) and pulmonary hemorrhage. Use of artificial surfactant has been associated with a significantly reduced length of time on ventilators and oxygen therapy, and an increased survival rate in preterm infants (see Medication Guide).

**Extracorporeal Membrane Oxygenation Therapy.** Infants with severe pulmonary dysfunction who are older than 34 weeks of gestation may be candidates for extracorporeal membrane oxygenation (ECMO) therapy. ECMO makes use of cardiopulmonary bypass to oxygenate the infant's blood outside the body through a membrane oxygenator. The membrane oxygenator serves as an artificial lung while the infant's lungs heal. Because of the massive systemic anticoagulation therapy required in the pump tubing and the increased risk for hemorrhage, the criteria for its use are very strict, and the use of this therapy is therefore limited (Schwartz, 2003). The risk for intraventricular hemorrhages in preterm infants is particularly high, and for this reason, ECMO therapy cannot be used in them. ECMO has been successful in the treatment of various acute and chronic lung diseases, including meconium aspiration syndrome and persistent pulmonary hypertension of the newborn (Cifuentes et al., 2003).

**High-Frequency Ventilation.** Other modes of ventilator therapies include high-frequency oscillator ventilation, jet ventilation, flow interruption ventilation, and liquid ventilation (Carlo, Martin, & Fanaroff, 2006; Schwartz, 2003). These methods of high-frequency ventilation work by providing smaller volumes of oxygen at a significantly more rapid rate (more than 300 breaths/min) than do traditional mechanical ventilators. As a result, the intrathoracic pressure is decreased, and along with this, the risk of barotrauma. In liquid ventilation, the surface tension is reduced whereas oxygenation is improved through the re-creation of a fetal lung environment. Instead of air pressure, an experimental oxygenated lipid solution is pumped continuously through the lungs.

**Nitric Oxide Therapy.** Inhaled nitric oxide (NO), delivered as a gas, causes potent and sustained pulmonary vasodilation in the pulmonary circulation (Schwartz, 2003; Stork, 2006). NO binds with hemoglobin in red blood cells and is inactivated after metabolism. In the few studies conducted with human infants, positive results were seen: oxygen saturation improved, and no toxic effects from methemoglobin or increased levels of nitrogen oxide were documented. NO shows much promise in reducing adverse respiratory sequelae of being born prematurely. Its use has reduced the need for invasive technologies such as ECMO. Neurodevelopmental outcomes are documented as improved at age 2 years following treatment with NO (Mestan, Marks, Hecox, Huo, & Schreiber, 2005).

### Weaning from Respiratory Assistance
Respiratory assistance is weaned slowly as the infant’s status improves. The infant is ready to be weaned from respiratory assistance once the ABG and oxygen saturation levels are maintained within normal limits. A spontaneous, adequate respiratory effort must be present, and the infant must show improved muscle tone during increased activity. Weaning is done in a stepwise and gradual manner. This may consist of the infant being extubated, placed on CPAP, and then weaned to oxygen by means of a hood or nasal cannula. Throughout the weaning process, the infant’s oxygen levels are monitored by pulse oximetry, tcPO2 monitoring, and blood gas levels.

The goal of weaning is the withdrawal of all oxygen support. However, some infants do not achieve this before discharge from the hospital and may require home oxygen therapy for several months. Throughout the weaning period, the infant is assessed for signs and symptoms indicating poor tolerance of the process. These include an increased pulse, respiratory distress, or cyanosis, or a combination of these. If these occur, the amount of oxygen being delivered is increased, and weaning proceeds more slowly while further assessments are done. Underlying causes of intolerance of weaning may be BPD, a PDA, or CNS damage.

### Nutritional Care
It is not always possible to provide enteral (by the GI route) nourishment to a high risk infant. Such infants are often too ill or weak to breastfeed or bottle feed because of respiratory distress or sepsis. Early enteral feeding of the asphyxiated neonate with a low Apgar score also is avoided to prevent bowel necrosis. In such cases, nutrition is provided...
parenterally. Those infants who require parenteral nutrition may have one or more of the following problems:

- Lack of a coordinated suck-and-swallow reflex
- Inability to suck because of a congenital anomaly
- Respiratory distress requiring aggressive ventilator support
- Asphyxiation with a potential for necrotizing enterocolitis

**Type of Nourishment.** The types of formulas used, the mode and volume of feeding, and the feeding schedule of the infant are determined on the basis of the findings yielded by assessment of the following variables:

- Initially, the birth weight, and then the current weight of the preterm infant
- Pattern of weight gain or loss (infants weighing less than 1500 g require more energy for growth and thermoregulation and may gain weight poorly with either breast or bottle feedings)
- Presence or absence of suck-and-swallow reflex in all infants at less than 35 weeks of gestation
- Behavioral readiness to take oral feedings
- Physical condition, including presence or absence of bowel sounds, abdominal distention, or bloody stools, as well as presence and degree of respiratory distress or apneic episodes
- Residual from previous feeding, if being gavage-fed
- Malformations (especially GI defects such as gastroschisis, omphalocele or esophageal atresia), including the need for a gastrostomy feeding tube
- Renal function, including urinary output and laboratory values (nitrogen balance, electrolyte balance, glucose level); preterm infants are especially susceptible to altered renal function

**Weight and Fluid Loss or Gain.** For many reasons, the caloric, nutrient, and fluid requirements of high risk infants are greater than those of the term, normal newborn. One reason is that premature or dysmature (malnourished) newborns often have limited stores of nutrients and fluids. In addition, symptomatic or asymptomatic hypoglycemia, electrolyte imbalances, or other metabolic disturbances can develop in an infant whose nutritional intake is poor. Such hypoglycemia may cause serious damage to carbohydrate-dependent brain cells.

The infant’s weight is measured and recorded daily, and the rate of weight loss or gain is calculated. Further depletion of weight and metabolic stores can occur as a result of one or a combination of the following factors:

- Birth asphyxia
- Increased respirations or respiratory effort
- PDA
- Hypothermic environment
- Insensible fluid loss caused by evaporation (with radiant heat or phototherapy)
- Vomiting, diarrhea, and dysfunctional absorption from the GI tract
- Growth demands (a preterm infant’s growth rate approximates that of fetal growth during the last trimester and is at least two times faster than a term infant’s growth rate after birth)
- Inability of the renal system to concentrate urine and maintain an adequate rate of urea excretion, as well as infant’s inadequate response to antidiuretic hormone

The high risk newborn is predisposed to have weight and fluid losses of the greater amount of fluid needed to meet the demands of the increased cellular metabolic processes (resulting from stress, repair, or growth). The body weight of preterm infants weighing less than 1500 g consists of 83% to 89% water, compared with the term infant’s water content of 71% (Denne, Poindexter, Leitch, Ernst, Lemons, & Lemons, 2002). Most of this water is in the extracellular fluid compartment. Even with the early institution of fluid and nutrition intake, the preterm infant’s weight and fluid losses seem exaggerated. Inadequate fluid intake, resulting from either delayed administration or insufficient volume, can further cause weight and fluid losses in the preterm infant.

**Insensible water loss (IWL)** is an evaporative loss that occurs largely through the skin. Approximately 30% of this IWL comes from the respiratory tract. The total IWL in a normal infant ranges anywhere from 30 to 60 ml/kg/24 hr. The effects of radiant warmers, incubators, phototherapy, and other factors can augment the IWL. Humidifying the respiratory gases administered can prevent some of this loss.

During the first week of extrauterine life, the preterm infant can lose up to 15% of his or her birth weight. In contrast, a weight loss of up to only 10% is acceptable in a term, appropriate-for-gestational-age (AGA) infant. After the initial week, a preterm infant’s loss or gain during each 24-hour period should not exceed 2% of the previous day’s weight. (To calculate a weight loss or gain, see Box 40-3.)

Increased stooling or voiding, increased evaporative losses, inadequate volume or incorrect fluid administration, and problems with malabsorption may cause weight loss. Implementation of interventions and frequent reassessment of the infant and its environment are necessary to correct the problems. Such interventions include adjusting the incubator temperature; “swamping” or providing high

### Box 40-3 Calculation of a Weight Loss or Gain

#### EXAMPLE 1

<table>
<thead>
<tr>
<th>Day</th>
<th>Weight (g)</th>
<th>% Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Day 1</td>
<td>1750</td>
<td>100%</td>
</tr>
<tr>
<td>Day 2</td>
<td>1680</td>
<td>4.0%</td>
</tr>
<tr>
<td>Day 3</td>
<td>1680</td>
<td>100%</td>
</tr>
<tr>
<td>Day 4</td>
<td>1720</td>
<td>2.38%</td>
</tr>
</tbody>
</table>

#### EXAMPLE 2

<table>
<thead>
<tr>
<th>Day</th>
<th>Weight (g)</th>
<th>% Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Day 3</td>
<td>1680</td>
<td>100%</td>
</tr>
<tr>
<td>Day 4</td>
<td>1720</td>
<td>2.38%</td>
</tr>
</tbody>
</table>

X = 2.4% weight gain
levels of humidity under a cover over the radiant warmer; monitoring and adjusting the volume and type of fluids being administered; assessing the urinary output, including the specific gravity; and assessing the blood glucose levels. The glucose determinations are used to assess urine osmolarity and hence renal function. High glucose levels (greater than 125 mg/dl) can stimulate an excessive osmotic osmolarity and hence renal function. High glucose levels. The glucose determinations are used to assess urine needs.

The nurse reports and records the findings and continues to assess the infant’s fluid status, urinary output, and blood glucose levels. The interventions implemented are determined by the infant's specific disorder and nutritional needs.

**Elimination Patterns.** The infant’s elimination patterns also are assessed. This includes the frequency of urination, as well as the amount, color, pH, and specific gravity of the urine. The assessment of the infant’s bowel movements includes the frequency of stooling and the character of the stool, as well as whether there is constipation, diarrhea, or loss of fats (steatorrhea). All of these findings are documented. The nurse may request guaiac tests to assess for blood in the stool, tests to detect stool-reducing substances, and a pH determination to assess for malabsorption. Infants with unexplained abdominal distention are assessed carefully to rule out the presence of hypomotility or obstructions of the GI tract.

**Oral Feeding.** Nourishment by the oral route is preferred for the infant who has adequate strength and GI function. The best milk for an infant is that of its mother. Breast milk may be fed by breast, bottle, or cup. Formula may be fed by bottle or a supplementer (see Fig. 27-2). Throughout the feeding, the nurse assesses the newborn’s tolerance of the procedure. The nurse assists the mother by providing support and help as necessary when the infant breastfeeds. Referral to a lactation consultant is important.

The needs of the high risk infant must be considered when determining the type and frequency of the feedings. Many high risk infants cannot suck well enough to breastfeed or bottle feed until they have recovered from their initial illness or matured physically (corrected age more than 32 weeks of gestation). Mothers of high risk infants are encouraged to continue pumping breast milk, especially if theirs is a very premature infant who may not breastfeed for many weeks. Because of the significant breastfeeding attrition rates among these mothers, they need support and encouragement every few days to continue pumping while their infant is not yet able to nurse. If no breast milk is available (from the mother or a milk bank), commercial formula is used. The calories, protein, and mineral content of commercial formulas vary (see Chapter 27). The type of nipple selected (“preemie,” regular, orthodontic) depends on the infant’s ability to suck from the specific type of nipple. The nurse also considers the energy the infant needs to expend in the process. However, the current practice of delaying breastfeeding until the baby is able to effectively bottle-feed is not evidence-based since studies continue to confirm that breastfeeding is less stressful than bottle-feeding (Callen & Pinelli, 2005).

Overfeeding of the preterm infant should be avoided because this can lead to abdominal distention, with apnea, vomiting, and possibly aspiration of the feeding. The nurse monitors the infant’s abdominal girth when distention is obvious.

**Gavage Feeding.** Gavage feeding is a method of providing nourishment to the infant who is compromised by respiratory distress, the infant who is too immature to have a coordinated suck-and-swallow reflex, or the infant who is easily fatigued by sucking. In gavage feeding, breast milk or formula is given to the infant through a nasogastric or orogastric tube (Fig. 40-7). This spares the infant the work of sucking.

Gavage feeding can be done either with an intermittently placed tube providing a bolus feeding or continuously through an indwelling catheter. Infants who cannot tolerate large bolus feedings (those on ventilators for more than a week) are given continuous feedings. Minimal enteral nutrition (MEN) may be used to stimulate or prime the GI tract to achieve better absorption of nutrients when bolus or regular intermittent gavage feedings can be given (Hawthorne et al., 2004; Tyson & Kennedy, 2002). Breast milk or formula can be supplied intermittently by using
a syringe with gravity-controlled flow, or it can be given continuously by using an infusion pump. The type of fluid instilled is recorded with every syringe change. The volume of the continuous feedings is recorded hourly, and the residual gastric aspirate is measured every 4 hours. Residuals of less than a fourth of a feeding can be refed to the infant to prevent the loss of gastric electrolytes. Feeding is usually stopped if the residual is greater than a quarter of the feeding and is not resumed until the infant can be assessed for a possible feeding intolerance.

The orogastric route for gavage feedings is preferred because most infants are preferential nose breathers. Also when indwelling nasogastric tubes are used, there is a tendency toward nares necrosis; however, some infants do not tolerate oral tube placement. A small nasogastric feeding tube can be placed in older infants who would otherwise gag or vomit or in ones who are learning to suck. To insert the tube and give the feeding, the nurse should follow the sequence given in the Procedure boxes.

**Gastrostomy Feedings.** Infants with certain congenital malformations require gastrostomy feedings. This involves the surgical placement of a tube through the skin of the abdomen into the stomach. The tube is then taped in an upright position to prevent trauma to the incision site. After the site heals, the nurse initiates small bolus feedings per the physician’s orders. Feedings by gravity are done slowly over 20- to 30-minute periods. Special care must

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**Procedure**

**Inserting a Gavage Feeding Tube**

1. Measure the length of the gavage tube from the tip of the nose to the lobe of the ear to the midpoint between the xiphoid process and the umbilicus (see Fig. 40-7, A). Mark the tube with a piece of tape.

2. Lubricate the tip of the tube with sterile water and insert gently through the nose or mouth (see Fig. 40-7, B) until the predetermined mark is reached. Placement of the tube in the trachea will cause the infant to gag, cough, or become cyanotic.

3. Check correct placement of the tube by
   a. Pulling back on the plunger to aspirate stomach contents. Lack of fluid is not necessarily evidence of improper placement. Respiratory secretions may be mistaken for stomach contents; however, the pH of the stomach contents is much lower (more acidic) than the pH of respiratory secretions.
   b. Injecting a small amount of air (1 to 3 ml) into the tube while listening for gurgling or by using a stethoscope placed over the stomach. Ensure that the tube is inserted to the mark; it is possible to hear air entering the stomach even if the tube is positioned above the gastroesophageal (cardiac) sphincter.

4. Tape the tube in place and also tape it to the cheek to prevent accidental dislodgment and incorrect positioning (see Fig. 40-7, C).
   a. Assess the infant’s skin integrity before taping the tube.
   b. Edematous or very premature infants should have a pectin barrier placed under the tape to prevent abrasions.*

5. Tube placement must be assessed before each feeding.

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be taken to prevent rapid bolusing of the fluid because this may lead to abdominal distention, GI reflux into the esophagus, or respiratory compromise. Meticulous skin care at the tube insertion site is necessary to prevent skin breakdown or infections. In addition, intake and output are monitored scrupulously because these infants are prone to diarrhea until regular feedings are established.

**Parenteral Fluids.** Feeding supplemental parenteral fluids is indicated for infants who are unable to obtain sufficient fluids or calories by enteral feeding (Fig. 40-8). Some of these infants are dependent on total parenteral nutrition (TPN) for extensive periods. The nurse assesses and documents the following in infants receiving parenteral fluids or TPN:

- **Type and infusion rate of the solution**
- **Functional status of the infusion equipment, including the tubing and infusion pump**
- **Infusion site for possible complications (phlebitis, infiltration, discouloration)**
- **Caloric intake**
- **Infant’s responses to therapy**

The physician or nurse practitioner orders TPN per the hospital protocol. These orders must specify the electrolytes and nutrients desired, as well as the volume and rate of infusion. The amounts of calories, protein, and fat are determined on the basis of the individual infant’s energy needs (Wyckoff, McGrath, Griffin, Malan, & White-Traut, 2003).

While caring for the infant receiving parenteral fluids or TPN, the nurse secures and protects the insertion site. In addition to observing the principles of asepsis, the nurse must observe the principles of neonatal skin care (Lund & Kuller, 2003). The nurse also should inspect the infusion site for signs of infiltration and repositional the infant frequently to maintain body alignment and protect the site. Parents of infants need to be given explanations about TPN and the way in which the IV equipment and solutions affect their infant.

**Advancing Infant Feedings.** Feedings are advanced as assessment data and the infant’s ability to tolerate the feedings warrant. Documentation of a preterm infant’s sucking patterns also can be used to determine its readiness to nipple feed. Feedings are advanced from passive (parenteral and gavage) to active (nipple and breastfeeding). At each step, the nurse must carefully assess the infant’s response to prevent overstressing the infant.

The infant receiving nutrition parenterally is gradually weaned off of this type of nutrition. To do this, the nourishment given by continuous or intermittent gavage feedings is increased while the parenteral fluids are decreased. Even the smallest infant is sometimes given MEN to stimulate the GI system to mature and to enhance caloric intake (Wyckoff et al., 2003).

Feedings are advanced slowly and cautiously because, if feedings are advanced too rapidly, the infant may vomit (with an attendant risk of aspiration), with diarrhea, abdominal distention, and apneic episodes. Rapid advancement of feedings also may cause fluid retention with cardiac compromise or a pronounced diuresis with hyponatremia.

If the infant needs additional calories, a commercial human milk fortifier can be added to the gavaged breast milk, or the number of calories per 30 ml of commercial formula can be increased. Soy and elemental formulas are used only for infants with very special dietary needs, such as allergies to cow’s milk or chronic malabsorption. Calories in breast milk can be lost if the cream separates and adheres to the tubing during continuous infusion. This problem is decreased if microbore tubing is used for both continuous and intermittent gavage feedings.
The infant receiving gavage feedings progresses to bottle feeding or breast milk feedings. To do this, the gavage feedings are decreased as the infant’s ability to suckle breast milk or formula improves. Often during this transition, the infant is fed by both nipple and gavage feeding to ensure the intake of both the prescribed volume of food and nutrients. However, when there is an indwelling tube, during nipple feedings, some infants experience an increased respiratory effort, so nurses must watch for this. The parents need support during this transition because many families measure their parenting competence by how well they can feed their infant. For breastfed infants, weighing before and after a feeding provides documentation of intake (1 gram gain = 1 ml intake), but should be used judiciously (Hall, Shearer, Mogan, & Berkowitz, 2002).

As the time of discharge nears, the appropriate method of feeding, as well as the assessments pertaining to the method (e.g., tolerance of feedings, status of gavage tube placement), are reviewed with the parents. The parents should be encouraged to interact with the infant by talking and making eye contact with the infant during the feeding. This interaction is encouraged to stimulate the psychosocial development of the infant and to facilitate bonding and attachment.

**Nonnutritive Sucking.** If the gavage or the parenteral route nourishes the infant, *nonnutritive sucking* is encouraged (Fig. 40-9) for several reasons. Allowing the infant to suck on a pacifier during gavage or between oral feedings may improve oxygenation. In addition, such nonnutritive sucking may lead to a decreased energy expenditure with less restlessness and to positive weight gain, and promote faster attachment to the nipple when oral feedings are initiated (Wyckoff et al., 2003).

Mothers of preterm infants should be encouraged to let their preterm infants start sucking at the breast during kangaroo care (skin-to-skin) because some infant’s suck-and-swallow reflexes may be coordinated as early as 32 weeks of gestation.

Infants with intrauterine growth restriction (IUGR) may have an age-appropriate sucking reflex but require thermoregulatory support, making it difficult to breastfeed. These infants also may benefit from nonnutritive sucking at the breast for short periods.

**Environmental Concerns**

Infants in NICUs also are exposed to high levels of auditory input from the various machine alarms, and this can have adverse effects (Fig. 40-10). In addition, continuous noise levels of 45 to 85 decibels (db) are common in NICUs. An incubator alone produces a constant noise level of 60 to 80 db, and each new piece of life-support equipment used adds another 20 db to the background noise. The infant’s hearing may be damaged if it is exposed to a constant decibel level of 90 db or frequent decibel swings higher than 110 db. Cochlear damage has been recognized as a side effect of the NICU environment. Thus both conductive and sensorineural hearing losses have been identified in NICU graduates; these losses lead to long-term speech and language deficits (Haubrich, 2003; Krueger, Wall, Parker, & Nealis, 2005). Based on research findings, Johnson (2003) developed and tested a protocol aimed at noise reduction in the NICU (Box 40-4). It needs to be tested for developmental long-term outcomes.

Respiratory equipment or a phototherapy mask may alter the infant’s vision, making it difficult for the infant to interact with caregivers and family members. The infant also may be unable to establish diurnal and nocturnal rhythms because of the continuous exposure to overhead lighting. In addition, sedation or pain medications affect the way in which the infant perceives the environment.

An additional concern in the care of infants is that some drugs used for infant therapy can potentiate environmental hazards. Diuretics (especially furosemide [Lasix]), antibiotics (gentamicin), and antimalarial agents can potentiate noise-induced hearing loss (Haubrich, 2003).
Research is ongoing to determine effects of light and noise on the preterm infant. Long-term problems are the focus of much research (Symington & Pinelli, 2003). Cycling of light and covering of isolettes to reduce direct light hitting the retina are two areas of research. The retina of the immature infant has little protection from the nearly translucent eyelid, thus allowing light to almost continuously penetrate the retina unless it is artificially protected by dimming the lights or using isolette covers. Brandon, Holditch-Davis, and Belyea (2003) have found that cycled lighting on the preterm infant has resulted in more positive growth patterns than if they are kept in very dim light. Light and sound are known adverse stimuli that add to an already stressed preterm infant. The result is stress cues, increased metabolic rates, increased oxygen and caloric use, and depression of the immune system. The nurse must monitor the macroenvironment and the microenvironment (unit and immediate environments) for sources of overstimulation. Providing a developmentally supportive environment can lead to decreased complications and lengths of stay. There are national recommendations for sound and light levels in the NICU.

**NURSE ALERT**

Routine hearing screening should be performed in all infants before discharge, with universal screening completed by no later than the third month of life.

Nurses can modify the environment to provide a developmentally supportive milieu. In that way, the infant’s neurobehavioral and physiologic needs can be met better, the infant’s developing organization can be supported, and growth and development fostered (Symington & Pinelli, 2003).

**Developmental Care**

The goal of developmental care is to support each infant’s efforts to become as well organized, competent, and stable as possible (Kenner & McGrath, 2004). Developmental care includes all care procedures and the physical and social aspects of care in the NICU (Als et al., 2004). The caregiver uses the infant’s own behavior and physiologic functioning as the basis for planning care and providing interventions. Through caregiver observation, the infant’s strengths, thresholds for disorganization, and areas in which the infant is vulnerable can be identified (Als et al.). The family is included in developmental care as the primary coregulators (Als et al.). Working together, the family and other caregivers provide opportunities to enhance the strengths of the family and the infant and to reduce the stress that is associated with the birth and care of high risk infants. In some settings, a “cuddler” participates in the care (a specially trained adult volunteer who holds, reads to, talks to, and consoles infant when the parents are unable to visit) (Steuber, Carroll, McCoy, & Nurney, 2002). Mothers of preterm infants need to be taught the importance of interactions with their infant since they tend to do this less than mothers of term infants (Holditch-Davis, Cox et al. 2003).

Reducing light and noise levels by instituting “quiet hours” during each 8 hour shift and positioning are just two of the ways in which nurses can support infants in their development. Sleep interruptions are minimized, and positioning and bundling the infant help promote self-regulation and prevent disorganization (Symington & Pinelli, 2003).

**Positioning.** The motor development of preterm infants permits less flexion than that in their term counterparts. Caregivers can provide a variety of positions for infants; side-lying and prone are preferred to supine (but only in the nursery) (Fig. 40-11). Body containment with use of blanket rolls, swaddling, holding the infant’s arms in a crossed position, and secure holding provide boundaries and promote self-regulation during feeding, procedures, and other stressful interventions (Hendricks-Muñoz, Prendergast, Caprio, & Wasserman, 2002). The prone position encourages flexion of the extremities; a sling or hip roll assists in maintenance of flexion. Use of a sheepskin prevents abrasion of the knees. However, there is some concern that fibers from sheepskin can be breathed in if the infant’s face is positioned near the sheepskin itself, so it should be used with caution. Hold-
ing the limbs close to the body when the infant is moved decreases stimulation that produces jerky, uncoordinated movements (Hockenberry, 2003). Proper body alignment is necessary to prevent developmental problems that may affect the ability to walk as the child matures.

Reducing Inappropriate Stimuli. Staff can reduce unnecessary noise by closing doors or portholes on incubators quietly, placing only necessary objects gently on top of incubators, keeping radios at low volume, speaking quietly, and handling equipment noiselessly. Earmuffs for the infant may be used to reduce auditory input (Hockenberry, 2003).

Infants can be protected from light by dimming the lights during the night, placing a blanket over the incubator (Fig. 40-12), or covering the infant’s eyes with a mask. Sleep-wake cycles can be induced with such measures. Infants need periods when they are completely undisturbed (Hockenberry, 2003).

Infant Communication. Infants communicate their needs and ability to tolerate sensory stimulation through physiologic responses. The nurses and parents of high risk infants must therefore be alert to such cues. Although term infants may thrive on stimulation, this same stimulation in high risk infants can instead provoke physical symptoms of stress and anxiety (Symington & Pinelli, 2003).

Problems with noxious stimuli and barriers to normal contact may cause anxiety and tension. Clues to overstimulation include averting the gaze, hiccuping, gagging, or regurgitating food. Term infants exhibit a startle reflex, and preterm infants move all of their limbs in an uncoordinated fashion in response to noxious stimuli. An irregular respiratory rate or an increased heart rate may develop in severely distressed infants, and they may then be unable to regain a calm state.

A relaxed infant state is indicated by stabilization of vital signs, closed eyes, and a relaxed posture. Nonintubated infants may make soothing verbal sounds when they are relaxed. Infants requiring artificial ventilation cannot cry audibly and often show their distress through posturing; they relax once their needs are met. As high risk infants heal and mature, they increasingly respond to stimuli in a self-regulated manner rather than with a dissociated response. Infants who do not show increased self-regulation should be evaluated for a neurologic problem.

Infant Stimulation. A neonatal individualized developmental care and assessment program (NIDCAP) routinely integrates aspects of neurodevelopmental theory with caregivers’ observations, environmental interventions, and parental support (Hendricks-Muñoz et al., 2002). Routine reassessment is built into the program’s design. Developmental stimuli may consist of such simple measures as placing a waterbed mattress on the top of the infant’s mattress or kangaroo (skin-to-skin) holding. The simplest calming technique is to contain the infant’s extremities close to the body with both hands. The care of the infant is organized to allow extended periods of undisturbed rest and sleep. Pain medications or sedatives should be administered consistently, per the unit’s protocol.

Infants acquire a sense of trust as they learn the feel, sound, and smell of their parents. High risk infants also must learn to trust their caregivers to obtain comfort (Fig. 40-13 and Fig. 40-14). However, caregivers in the nursery...
also may inflict pain as part of the care they must give. For this reason, it is important for both the parents and the caregivers of infants to use comforting interventions such as removing painful stimuli, stopping hunger, and changing wet or soiled clothing to foster trust. They can offer nonnutritive sucking opportunities or use oral sucrose for pain relief and topical creams before procedures to avoid the sensation of pain. All of these techniques are part of developmental, supportive care.

When the infant is ready for stimulation, the nurse has many options. All infants can tolerate being held, even if only for short periods. Additional ways for the nurse or parents to stimulate infants include cuddling, rocking, singing, use of music therapy, and talking to the infant. These activities are beneficial, increase weight gain, and decrease time to discharge (Standley, 2002). Stroking the infant’s skin during medical therapy can provide tactile stimulation. The caregiver responds to the infant’s cues by offering reassurance, providing nonnutritive sucking, stroking the infant’s back, and talking to the infant. Infant massage is gaining evidence as a way to promote weight gain (Diego, Field, & Hernandez-Reif, 2005).

Mobiles and decals that can be changed frequently also may be placed within the infant’s visual range to stimulate the infant visually. Wind-up musical toys provide rhythmic distractions as long as they are not too loud. If the infant is receiving phototherapy, the protective eye patches are removed periodically (e.g., during feeding) so that the infant can see the caregiver’s face for short, comforting sessions.

Kangaroo Care. Kangaroo care (skin-to-skin holding) (see Fig. 40-4) helps infants to interact directly with their parents. In this technique, the infant, dressed only in a diaper, is placed directly on the parent’s bare chest and then covered with the parent’s clothing or a warmed blanket. In this way, the parent’s body temperature also functions as an external heat source that enhances the infant’s ket. In this way, the parent’s body temperature also functions as an external heat source that enhances the infant’s ket. The important and purpose of the apparatus that surrounds their infant also should be explained to them.

To assess the parents’ perceptions of the infant to determine the appropriate time for them to become actively involved in care.

As soon as possible after the birth, the parents are given the opportunity to meet the infant in the *en face* position, to touch the infant, and to see him or her favorable characteristics. Mothers often state that their greatest source of stress is the appearance of their baby (Miles, Burchinal, Holditch-Davis, Brunssen, & Wilson, 2002). As soon as possible, depending primarily on her physical condition, the mother is encouraged to visit the nursery as desired and help with the infant’s care. When the family cannot be present physically, staff members devise appropriate methods to keep them in almost constant touch with the newborn, such as with daily phone calls, notes written as if by the infant, or photographs of the infant.

Some hospitals have support groups for the parents of infants in NICUs. These groups help parents experiencing anxiety and grief by encouraging them to share their feelings. Hospitals also often arrange to have an experienced NICU parent make contact with a new group member to provide additional support. The volunteer parents provide support by making hospital visits, phone calls, and home visits. Mothers in particular are prone to posttraumatic stress that may hinder their ability to interact or care for their infant (Holditch-Davis, Bartlett, Blickman, & Miles, 2003).

**Parental Support**

The nurse as the support person and teacher is responsible for shaping the environment and making the care giving responsive to the needs of the parents and infant. Nurses are instrumental in helping parents learn who their infant is and to recognize behavioral cues in his or her development and using these cues in the care they provide (Liaw, Yuh, & Chang, 2005).

If a high risk birth has been anticipated, the family can be given a tour of the NICU or shown a video to prepare them for the sights and activities of the unit. After the birth, the parents can be given a booklet, be shown a video, or have someone describe what they will see when they go to the unit to see their infant. As soon as possible, the parents should see and touch their infant so that they can begin to acknowledge the reality of the birth and the infant’s true appearance and condition. They will need encouragement as they begin to accomplish the psychologic tasks imposed by the high risk birth. For the following reasons, a nurse or physician should be present during the parents’ first visit to see the infant:

- To help them “see” the infant rather than focus on the equipment. The importance and purpose of the apparatus that surrounds their infant also should be explained to them.
- To explain the characteristics normal for an infant of their baby’s gestational age; in this way parents do not compare their child with a term, healthy infant.
- To encourage the parents to express their feelings about the pregnancy, labor, and birth and the experience of having a high risk infant.
- To assess the parents’ perceptions of the infant to determine the appropriate time for them to become actively involved in care.
They need help in expressing their feelings and, when appropriate, referral for psychologic or family counseling.

Many NICUs use volunteers in varying capacities. After they have gone through the orientation program, volunteers can perform tasks such as holding the infants, stocking bedside cabinets, assembling parent packets, and, in some nurseries, feeding the infants.

Some high-risk infants can be discharged earlier than the expected time. The criteria showing an infant’s readiness for early discharge are that the infant’s physiologic condition is stable, the infant is receiving adequate nutrition, and the infant’s body temperature is stable. The parents, or other caregivers, also need to exhibit a physical, emotional, and educational readiness to assume responsibility for the care of the infant. Ideally, the home environment is adequate for meeting the needs of the infant. The parents also need to show that they know the way to take the infant’s temperature, know the signs and symptoms to report, and understand the dietary needs of the infant. Resources for parents and health care providers include http://premature-infant.com, www.vort.com/age/premature.html, www.neonatology.org, and www.familyvillage.wisc.edu.

**Parent Education**

*Cardiopulmonary Resuscitation.* Sudden infant death syndrome (SIDS) is 8 to 10 times more likely to develop in preterm infants than in term infants. Furthermore, it has been found that infants discharged from an NICU are about twice as likely to die unexpectedly during the first year of life as are infants in the general population. Instruction in cardiopulmonary resuscitation (CPR) is essential for parents of all infants but especially for those of infants at risk for life-threatening events (see Chapter 28). Infants considered at risk include those who are preterm, have apnea or bradycardia spells, or have a tendency to choke. Before taking their infant home, parents must be able to administer CPR. All parents should be encouraged to obtain instruction in CPR at their local Red Cross or other community agency, if it is not provided by the NICU.

**Evaluation**

The nurse uses the previously stated expected outcomes of care to evaluate the effectiveness of the physical and psychosocial aspects of care (see Plan of Care).

**COMPPLICATIONS IN HIGH RISK INFANTS**

**Respiratory Distress Syndrome**

Respiratory distress syndrome (RDS) refers to a lung disorder usually affecting preterm infants. Maternal and fetal conditions associated with a decreased incidence and severity of RDS include female infant, African-American race, maternal gestational hypertension, maternal drug abuse, maternal steroid therapy (betamethasone), chronic retroplacental abruption, prolonged rupture of membranes, and IUGR. The incidence and severity of RDS increase with a decrease in the gestational age. Perinatal asphyxia, hypovolemia, male infant, Caucasian race, maternal diabetes (types 1 and 2), second-born twin, familial predisposition, maternal hypotension, cesarean birth without labor, hydrops fetalis, and third-trimester bleeding are all factors that place an infant at increased risk for RDS. The incidence of RDS in infants weighing less than 1500 g is between 40% and 60% (Cifuentes et al., 2003; Schwartz, 2003).

RDS is caused by a lack of pulmonary surfactant, which leads to progressive atelectasis, loss of functional residual capacity, and a ventilation/perfusion imbalance with an uneven distribution of ventilation. This surfactant deficiency may be caused by insufficient surfactant production, abnormal composition and function, disruption of surfactant production, or a combination of these factors. The weak respiratory muscles and an overly compliant chest wall, common among preterm infants, further compromise the sequence of events that occurs. Lung capacity is further compromised by the presence of proteinaceous material and epithelial debris in the airways. The resulting decreased oxygenation, cyanosis, and metabolic or respiratory acidosis can cause the pulmonary vascular resistance (PVR) to be increased. This increased PVR can lead to right-to-left shunting and a reopening of the ductus arteriosus and foramen ovale (Fig. 40-15).

Clinical symptoms of RDS are listed in Box 40-5. These respiratory signs usually appear immediately after birth or within 6 hours of birth. Physical examination reveals crackles, poor air exchange, pallor, the use of accessory muscles (retractions) and, occasionally, apnea. Radiographic findings include a uniform reticulogranular appearance and air bronchograms (Rodriguez, Martin, & Fanaroff, 2006). The infant’s clinical course typically is variable, with usually an increased oxygen requirement and increased respiratory effort as atelectasis, a loss of functional residual capacity, and ventilation/perfusion imbalance worsen.

However, RDS is a self-limiting disease, with the respiratory symptoms abating after 72 hours. This disappearance of respiratory signs coincides with the production of surfactant in the type 2 cells of the alveoli.

The treatment for RDS is supportive. Adequate ventilation and oxygenation must be established and maintained in an attempt to prevent ventilation/perfusion mismatch and atelectasis. Exogenous surfactant may be administered
**NURSING DIAGNOSIS** Ineffective breathing pattern related to pulmonary and neuromuscular immaturity, decreased energy, fatigue

**Expected Outcomes** Infant exhibits adequate oxygenation (i.e., arterial blood gases [ABGs] and acid-base within normal limits [WNL]; oxygen saturations 92% or greater; respiratory rate and pattern WNL; breath sounds clear; and absence of grunting, nasal flaring, minimal retractions, skin color WNL).

**Nursing Interventions/Rationales**
- Position neonate prone or supine, avoiding neck hyperextension to promote optimum air exchange. Use a side-lying position after feeding or in cases of excessive mucus production to avoid aspiration. Avoid Trendelenburg position because it can cause increased intracranial pressure and reduce lung capacity.
- Suction nasopharynx, trachea, and endotracheal tube as indicated to remove mucus. Avoid oversuctioning because it can cause bronchospasm, bradycardia, and hypoxia and predispose neonate to intraventricular hemorrhage.
- Administer percussion, vibration, and postural drainage as prescribed to facilitate drainage of secretions.
- Administer oxygen and monitor neonatal response to maintain oxygen saturation.
- Maintain a neutral thermal environment to conserve oxygen use.
- Monitor arterial blood gases, acid-base balance, oxygen saturation, respiratory rate and pattern, breath sounds, and airway patency; observe for grunting, nasal flaring, retractions, and cyanosis to detect signs of respiratory distress.

**NURSING DIAGNOSIS** Ineffective thermoregulation related to immature temperature regulation and minimal subcutaneous fat stores

**Expected Outcome** Infant exhibits maintenance of stable body temperature within normal range for postconceptional age (36.5°C to 37.2°C).

**Nursing Interventions/Rationales**
- Place neonate in a prewarmed radiant warmer to maintain stable temperature.
- Place temperature probe on neonatal abdomen to control heat levels in radiant warmer.
- Take axillary temperature periodically to monitor temperature and cross-check functioning of warmer unit.
- Avoid infant exposure to cool air and drafts, cold scales, cold stethoscopes, cold examination tables, and prolonged bathing that predispose the infant to heat loss.
- Monitor probe frequently since detachment can cause overheating or warmer-induced hyperthermia.
- Transfer infant to a servocontrolled open warmer bed or incubator when temperature has stabilized.

**NURSING DIAGNOSIS** Risk for infection related to immature immune system

**Expected Outcome** Infant exhibits no evidence of nosocomial infection.

**Nursing Interventions/Rationales**
- Institute scrupulous handwashing techniques before and after handling neonate, ensure all supplies and/or equipment are clean before use, and ensure strict aseptic technique with invasive procedures to minimize exposure to infective organisms.
- Prevent contact with persons who have communicable infections, and instruct parents in infection-control procedures to minimize infection risk.
- Administer prescribed antibiotics to provide coverage for infection during sepsis workup.
- Continuously monitor vital signs for stability since instability, hypothermia, or prolonged temperature elevations serve as indicators for infection.

**NURSING DIAGNOSIS** Risk for imbalanced nutrition: less than body requirements related to inability to ingest nutrients secondary to immaturity

**Expected Outcomes** Infant receives adequate amount of nutrients with sufficient caloric intake to maintain positive nitrogen balance; demonstrates steady weight gain.

**Nursing Interventions/Rationales**
- Administer parenteral fluid/total parenteral nutrition (TPN) as prescribed to provide adequate nutrition and fluid intake.
- Monitor for signs of intolerance to TPN, which can interfere with effective replenishment of nutrients.
- Periodically assess readiness to orally feed (i.e., strong suck, swallow, and gag reflexes) to provide appropriate transition from TPN to oral feeding as soon as neonate is ready.
- Advance volume and concentration of formula when orally feeding per unit protocol to avoid overfeeding and feeding intolerance.
- If mother desires to breastfeed when neonate is stable, demonstrate how to express milk to establish and maintain lactation until infant can breastfeed.

**NURSING DIAGNOSIS** Risk for deficient fluid volume/excess fluid volume related to immature physiology

**Expected Outcome** Infant exhibits evidence of fluid homeostasis.

**Nursing Interventions/Rationales**
- Administer parenteral fluids as prescribed and regulate carefully to maintain fluid balance. Avoid hypertonic fluids such as undiluted medications, and concentrated glucose because they can cause excess solute load on immature kidneys.
- Implement strategies (e.g., use of plastic covers and increase ambient humidity) that minimize insensible water loss.
- Monitor hydration status (i.e., skin turgor, blood pressure, edema, weight, mucous membranes, fontanels, urine specific gravity, electrolytes) and intake and output to evaluate for evidence of dehydration or overhydration.

**NURSING DIAGNOSIS** Risk for impaired skin integrity related to immature skin structure, immobility, or invasive procedures

**Expected Outcome** Infant’s skin remains intact, with no evidence of irritation or injury.

**Nursing Interventions/Rationales**
- Cleanse skin as needed with plain warm water and apply moisturizing agents to skin to prevent dryness and reduce friction across skin surface.
- When performing procedures: minimize use of tape and apply a skin barrier between tape and skin; use transparent elastic film for securing central and peripheral lines; use limb electrodes for monitoring or attach with hydrogel and rotate electrodes frequently; remove adhesives with soap and water rather than alcohol or acetone-based adhesive removers to minimize skin damage.
- Monitor use of thermal devices such as warmers or heating pads carefully to prevent burns.
at birth or shortly after birth, and this has the effect of altering the typical course of RDS. Positive-pressure ventilation, bubble CPAP, and oxygen therapy may be needed during the respiratory illness. However, the prevention of complications associated with mechanical ventilation also is critical. These complications include pulmonary interstitial emphysema, pneumothorax, pneumomediastinum, and pneumopericardium. The mortality and morbidity rates associated with RDS are attributed to the immature organ systems of the infant and the complications associated with the treatment of the disease (Rodriguez et al., 2006).

Acid-base balance is evaluated by monitoring the ABG values (Table 40-2). Frequent blood sampling requires arterial access either by umbilical artery catheterization or by a peripheral arterial line. Pulse oximetry and transcutaneous carbon dioxide and oxygen monitors document trends in ventilation and oxygenation. Capillary blood gas values indicate the pH and PCO2 status in infants who are in more stable condition.

The maintenance of an NTE continues to be of critical importance in infants with RDS because infants with hypoxemia are unable to increase their metabolic rate when cold stressed (Rodriguez et al., 2006).

The clinical and radiographic presentation (radiodense lung fields and air bronchograms) of neonatal pneumonia may be similar to that of RDS. Fluid in the minor tissue also may be noted in infants with neonatal pneumonia. Occasionally a lumbar puncture is done as part of the sepsis evaluation. Broad-spectrum antibiotics are begun while the results of cultures are awaited. Therefore sepsis evaluation, including blood culture and complete blood count (CBC) with differential, is done in infants with RDS to rule out neonatal pneumonia. Occasionally a lumbar puncture is done as part of the sepsis evaluation. Broad-spectrum antibiotics are begun while the results of cultures are awaited.

Fluid and nutrition must be maintained in the critically ill infant with RDS. Parenteral nutrition can be implemented to provide protein and fats to promote a positive nitrogen balance. Daily monitoring of the electrolyte values, urinary output, specific gravity, and weight help evaluate the infant’s hydration status.
Frequent blood sampling may make blood transfusions necessary. The critically ill infant usually needs to have a venous hematocrit level of more than 40% to maintain adequate oxygen-carrying capacity.

**NURSE ALERT**
Directed-donor blood may be requested. This donor blood usually is obtained from a family member or close friend of the family who has the same blood type as the infant or a compatible blood type. It may be necessary to notify the infant’s family of the potential need for blood transfusion on admission to allow for the processing of directed-donor blood.

Reassuring the family that stringent testing of all blood products is done may alleviate some of their anxiety about the transmission of blood-borne pathogens such as human immunodeficiency virus (HIV) and hepatitis B. Because some religions prohibit the use of blood transfusions, it is critical to obtain a complete history from the family, including their religious preference. Alternative strategies for maintaining the hematocrit may be used in these instances.

**Complications Associated with Oxygen Therapy**

**Retinopathy of Prematurity**
Retinopathy of prematurity (ROP) is a complex multi-cause disorder that affects the developing retinal vessels of preterm infants. The normal retinal vessels begin to form in utero at approximately 16 weeks in response to an unknown stimulus. These vessels continue to develop until they reach maturity at approximately 42 to 43 weeks after conception. Once the retina is completely vascularized, the retinal vessels are not susceptible to ROP. The mechanism of injury in ROP is unclear. Oxygen tensions that are too high for the level of retinal maturity initially result in vasoconstriction. After oxygen therapy is discon-

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**Table 40-2** Normal Arterial Blood Gas Values for Neonates

<table>
<thead>
<tr>
<th>VALUE</th>
<th>RANGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>7.32-7.49</td>
</tr>
<tr>
<td>Arterial oxygen pressure (Pao₂)</td>
<td>60-70 mm Hg</td>
</tr>
<tr>
<td>Carbon dioxide pressure (Paco₂)</td>
<td>26-41 mm Hg</td>
</tr>
<tr>
<td>Bicarbonate (HCO₃)</td>
<td>16-24 mEq/L</td>
</tr>
<tr>
<td>Oxygen saturation</td>
<td>40%-90%</td>
</tr>
</tbody>
</table>

Bronchopulmonary Dysplasia

Bronchopulmonary dysplasia (BPD) is a chronic pulmonary iatrogenic condition caused by barotrauma from pressure ventilation and oxygen toxicity. The etiology of BPD is multifactorial and includes pulmonary immaturity, surfactant deficiency, lung injury and stretch, barotrauma, inflammation caused by oxygen exposure, fluid overload, ligation of a PDA, and a familial predisposition. With the advent of prenatal use of maternal steroids when preterm birth is expected coupled with use of exogenous surfactant in the neonate, most BPD or chronic lung disease (CLD) has been eliminated.

Clinical signs of BPD include tachypnea, retractions, nasal flaring, increased work of breathing, exercise intolerance (to handling and feeding), and tachycardia. Auscultation of the lung fields in affected infants typically reveals crackles, decreased air movement, and occasionally expiratory wheezing. The treatment for BPD includes oxygen therapy, nutrition, fluid restriction, and medications (diuretics, corticosteroids, bronchodilators). However, the key to the management of BPD is prevention by preventing prematurity and RDS and by using surfactant and other less toxic therapies. Use of high-frequency ventilation and nitric oxide has contributed to the decline of this condition.

The prognosis for infants with BPD depends on the degree of pulmonary dysfunction. Most deaths occur within the first year of life as a result of cardiorespiratory failure, sepsis, or respiratory infection; in some infants, the deaths are sudden and unexplained (Cifuentes et al., 2003; Schwartz, 2003).

Patent Ductus Arteriosus

The ductus arteriosus is a normal muscular contractile structure in the fetus connecting the left pulmonary artery and the dorsal aorta. The duct constricts after birth as oxygenation, the levels of circulating prostaglandins, and the muscle mass increase. Other factors that promote ductal closure include catecholamines, low pH, bradykinin, and acetylcholine. When the fetal ductus arteriosus fails to close after birth, patent ductus arteriosus (PDA) occurs. During the first few days of life when a preterm or sick infant is under stress, this ductus arteriosus can reopen, leading to mottling and cyanosis. It may last only a few minutes until the stress is past, or it may remain open if the infant is quite unstable. The incidence of PDA in preterm infants is 20%, with an increasing incidence in VLBW infants and those with pulmonary disease (Carlo et al., 2006).

The clinical presentation in an infant with a PDA includes systolic murmur, active precordium, bounding peripheral pulses, tachycardia, tachypnea, crackles, and hepatomegaly. The systolic murmur is heard best at the second or third intercostal space at the upper left sternal border. An increased left ventricular stroke volume causes an active precordium. In addition, a widened pulse pressure may result in an increase in peripheral pulses.

Radiographic studies in infants with PDA typically show cardiac enlargement and pulmonary edema. ABG findings reveal hypercapnia and metabolic acidosis. Echocardiography can demonstrate a PDA and can measure the amount of blood shunting across the PDA.

The PDA can be managed medically or surgically. Medical management consists of ventilatory support, fluid restriction, and the administration of diuretics and indomethacin. Indomethacin is a prostaglandin synthetase inhibitor that blocks the effect of the arachidonic acid products on the ductus and causes the PDA to constrict (Rodriguez et al., 2006). Some evidence indicates that use of indomethacin may contribute to the incidence of ROP, but further research must be done. Ventilatory support is adjusted based on the ABG values. Fluid restriction is implemented to decrease cardiovascular volume overload in association with the diuretic therapy. Surgical ligation is done when a PDA is clinically significant and medical management has failed (Rodriguez et al.).

The nursing care of the infant with PDA focuses on supportive care. The infant needs an NTE, adequate oxygenation, meticulous fluid balance, and parental support.

Germinal Matrix Hemorrhage-Intraventricular Hemorrhage

Germinal matrix hemorrhage-intraventricular hemorrhage (GMH-IVH) is one of the most common types of brain injury that occurs in neonates and is among the most severe from the standpoint of both short-term and long-term outcomes. The true incidence of GMH-IVH is unknown, but the incidence is decreasing. The average incidence ranges from 5% to 11% (de Vries, 2006). The decline in
incidence is attributed to the prenatal use of corticosteroids and postnatal use of surfactant.

The pathogenesis of GMH-IVH includes intravascular factors (fluctuating or increasing cerebral blood flow, increases in cerebral venous pressures, and coagulopathy), vascular factors, extravascular factors, and nursery care. GMH-IVH events typically occur within the first hours or days of life. The exact location of this hemorrhage varies with gestational age. In the very immature infant (younger than 28 weeks), it usually occurs in or adjacent to the germinal matrix.

GMH-IVH is classified according to a grading system of I to III, with grade I being the least severe, and grade III, the most severe (de Vries, 2006) (Table 40-3).

The long-term neurodevelopmental outcome is determined by the severity of the GMH-IVH. Infants with small hemorrhages usually have good outcomes; infants with posthemorrhagic ventricular dilation and those that require shunt diversion often have long-term morbidity (de Vries, 2006). Hemorrhage associated with a lesion in the area of the periventricular white matter results in necrosis that alters cerebral brain flow in the affected area. This condition is referred to as periventricular leukomalacia (PVL).

Nursing care focuses on recognition of factors that increase the risk of GMH-IVH and PVL, interventions to decrease the risk of bleeding, and supportive care to infants who have bleeding episodes. The infant is positioned with the head in midline and the head of the bed elevated slightly to prevent or minimize fluctuations in intracranial blood pressure. NTE is maintained, as well as oxygenation. Rapid infusions of fluids should be avoided. Blood pressure is monitored closely for fluctuations. The infant is monitored for signs of pneumothorax because it often precedes GMH-IVH.

### table 40-3 Grading System for Neonatal Intraventricular Hemorrhage

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>GENERIC TERM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade I: Germinal matrix hemorrhage</td>
<td>GMH-IVH</td>
</tr>
<tr>
<td>Grade II: Intraventricular hemorrhage without ventricular dilation</td>
<td>GMH-IVH</td>
</tr>
<tr>
<td>Grade III: Intraventricular hemorrhage with acute ventricular dilation (clot fills &gt;50% of the ventricle)</td>
<td>GMH-IVH and ventriculomegaly</td>
</tr>
<tr>
<td>Intraparenchymal lesion—describe size, location</td>
<td>Intraparenchymal hemorrhage</td>
</tr>
</tbody>
</table>


### box 40-6 Proposed Risk Factors for Necrotizing Enterocolitis

- Asphyxia
- Respiratory distress syndrome
- Umbilical artery catheter
- Exchange transfusion
- Early enteral feedings/hyperosmolar feedings
- Patent ductus arteriosus
- Congenital heart disease
- Polycythemia
- Anemia
- Shock
- Gastrointestinal infection

### Necrotizing Enterocolitis

Necrotizing enterocolitis (NEC) is an acute inflammatory disease of the GI mucosa, commonly complicated by perforation. This often fatal disease occurs in about 2% to 5% of newborns in NICUs. Although the cause is unknown, the factors listed in Box 40-6 are known to contribute to its development. Breastfeeding seems to lower the incidence of NEC, as does use of minimal enteral nutrition.

Reversal of perinatal asphyxia within 30 minutes may prevent GI tract insult and thus prevent the pathophysologic events that trigger NEC. After 30 minutes, the distribution of cardiac output tends to be directed more toward the heart and brain and away from the abdominal organs. Therefore prompt birth of the intrauterine-asphyxiated fetus or ventilation of the asphyxiated newborn may be beneficial to the GI tract, as well as to other organs.

The onset of NEC in the term infant usually occurs between 4 and 10 days after birth. In the preterm infant, the onset may be delayed for up to 30 days. The signs of developing NEC are nonspecific, which is characteristic of many neonatal diseases. Some generalized signs include decreased activity, hypotonia, pallor, recurrent apnea and bradycardia, decreased oxygen saturation values, respiratory distress, metabolic acidosis, oliguria, hypotension, decreased perfusion, temperature instability, and cyanosis. GI symptoms include abdominal distention, increasing or bile-stained residual gastric aspirates, vomiting (bile or blood), grossly bloody stools, abdominal tenderness, and erythema of the abdominal wall.

A diagnosis of NEC is confirmed by a radiographic examination that reveals bowel loop distention, pneumatosis intestinalis (air in the wall of the bowel), pneumoperitoneum, portal air, or a combination of these findings. The abnormal radiographic findings are caused by the bacterial colonization of the GI tract associated with NEC, resulting in ileus. Pneumatosis intestinalis, pneumoperitoneum, and portal air are caused by gas produced by the bacteria that invade the wall of the intestines and escape into the peritoneal cavity. This often fatal disease occurs in about 2% to 5% of newborns in NICUs. Although the cause is unknown, the factors listed in Box 40-6 are known to contribute to its development. Breastfeeding seems to lower the incidence of NEC, as does use of minimal enteral nutrition.
increased or decreased. The platelet count and coagulation study findings may be abnormal, showing thrombocytopenia and disseminated intravascular coagulation (DIC). Electrolyte levels may be abnormal, with leaking capillary beds and fluid shifts with the infection.

Treatment in such infants is supportive. Oral or tube feedings are discontinued to rest the GI tract. An orogastric tube is placed and attached to low wall suction to provide gastric decompression. Parenteral therapy (often TNF) is begun. Because NEC is an infectious disease, control of the infection is imperative, with an emphasis on careful handwashing before and after infant contact. Antibiotic therapy may be instituted, and surgical resection is performed if perforation or clinical deterioration occurs. Therapy is usually prolonged, and recovery may be delayed by the formation of adhesions, the development of the complications associated with bowel resection, the occurrence of short-bowel syndrome (especially if the ileocecal valve is removed), or the development of intolerance to oral feedings. Some of these infants are candidates for intestinal transplants if they truly have short-bowel syndrome.

A decrease in the incidence of NEC correlates with feedings of breast milk (Caplan, 2006). Use of natural prophylactic probiotics such as *Bifidobacteria infantis*, *Streptococcus thermophilus*, and *Bifidobacteria bifidus* to enhance bowel flora appears to decrease the incidence of NEC. Bin-Nun and colleagues (2005) found a decreased incidence and severity of NEC when it did occur among those infants given probiotics as compared to those who did not receive the supplement.

## INFANT PAIN RESPONSES

The physiology of pain and pain assessment in the newborn were discussed in Chapter 26. This discussion focuses on pain assessment and management in the preterm infant.

### Pain Assessment

Assessment of pain in the neonate is difficult because evaluation must be based on physiologic changes and behavioral observations. Pain is now considered the fifth vital sign, and its assessment is a requirement of the Joint Commission on Accreditation of Healthcare Organizations (JCAHO). A scale that examines multiple dimensions is more accurate (Spence, Gillies, Harrison, Johnston, & Nagy, 2005). Although behaviors such as vocalizations, facial expressions, body movements, and general state are common to all infants, they vary with different situations. Crying associated with pain is more intense and sustained. Facial expression is the most consistent and specific characteristic; scales are available for systematic evaluation of facial features, such as eye squeeze, brow bulge, and open mouth and taut tongue (Walden & Franck, 2003) (see Fig. 26-20). Most infants respond with increased body movements, but the infant may be experiencing pain even when lying quietly with eyes closed. The preterm infant’s response to pain may be behaviorally blunted or absent.

An infant who receives a muscle-paralyzing agent such as vecuronium will be incapable of mounting a behavioral or visible pain response (Box 40-7), yet the infant still feels the pain.

### NURSE ALERT

When in doubt about the presence of pain in infants, base your decision for the need for intervention on the following rule: Whatever is painful to an adult or child is painful to an infant unless proved otherwise. Anticipate pain; do not wait for pain symptoms to appear before intervening.

Several tools have been developed for the assessment of pain in the neonate. The CRIES assessment tool is discussed in Chapter 26 (see Table 26-3). Other instruments that are used are the Pain Assessment Tool (PAT) (Hodgkinson, Bear, Thorn, & Van Blaricum, 1994); Scale for Use in Newborns (SUN) (Blauer & Gerstmann, 1998); Behavioral Pain Score (BPS) (Pokela, 1994); Distress Scale for Ventilated Newborn Infants (DSVNI) (Sparshott, 1995); Neonatal Infant Pain Scale (NIPS) (Lawrence, Alcock, McGrath, Kay, MacMurray, & Dulberg, 1993); and the Premature Infant Pain Profile (PIPP) (Stevens, Johnston, Petryshen, & Taddio, 1996). The PIPP is one of the most widely used scales for preterm infants since it considers behavioral, physiologic, and contextual indicators (Stevens, Johnston, Franck, Petryshen, Jack, & Foster, 1999; Walden & Franck, 2003).

### Memory of Pain

Preterm infants are subjected to a variety of repeated noxious stimuli, including multiple heel sticks, venipuncture, endotracheal intubation and suctioning, arterial sticks, chest tube placement, and lumbar puncture. The effects of pain caused by such procedures are not fully known, but researchers have begun to investigate potential consequences. From preliminary reports, it appears that a rewiring of the pain responses occurs in preterm infants who have been subjected to multiple painful treatments early in their lives. The nervous system networks of the preterm infant appear more dense and have more branches than those in the average infant, leading to the conclusion that the pain threshold and sensitivity in once preterm infants is heightened for life. There are also changes when the infant has undergone anesthesia (Anand, Johnston, Oberlander, Taddio, Lehr, & Walco, 2005; Aranda, Carlo, Hummel, Thomas, Lehr, & Anand, 2005).

Nurses’ anecdotal reports suggest that infants show memory by exhibiting defensive behaviors when painful procedures are repeated. Nurses often describe infants who stiffen and withdraw when touched because human touch has repeatedly been associated with pain. Such infants often become hypervigilant and gaze intently at the hands rather than at the eyes of people who approach them.

These reports not only indicate that infants remember painful events but also show that continual exposure to pain affects development, especially in response to human contact.
Consequences of Untreated Pain in Infants

Despite current research on the neonate’s experience of pain, infant pain remains inadequately managed. The mismanagement of infant pain is partially due to misconceptions regarding the effects of pain on the neonate, as well as a lack of knowledge of immediate and long-term consequences of untreated pain. Infants respond to noxious stimuli through physiologic indicators (increased heart rate and blood pressure, variability in heart rate and intracranial pressure, and decreases in arterial oxygen saturations and skin blood flow) and behavioral indicators (muscle rigidity, facial expression, crying, withdrawal, and sleeplessness). The physiologic and behavioral indicators, as well as a variety of neurophysiologic responses to noxious stimulation, are responsible for short-term and long-term consequences of pain.

Pain Management

The International Evidence-Based Group for Neonatal Pain developed a Consensus Statement for the Prevention and Management of Pain in the Newborn (Anand, 2001). This statement states that pain must be anticipated and prevented to avoid long-term consequences. Nonpharmacologic measures to alleviate pain include repositioning, swaddling, containment, cuddling, rocking, music, reducing environmental stimulation, tactile comfort measures, nonnutritive sucking, and use of oral sucrose (Walden & Franck, 2003). However, nonpharmacologic measures may not be sufficient to decrease physiologic distress, even if behavioral responses such as crying are lessened (Walden & Franck). In preterm infants, additional stimulation such as stroking or environmental light or noise may increase physiologic distress (Walden & Franck). The impact of the NICU environment must be considered along with other forms of stimuli that may produce stress and pain.

Morphine is the most widely used opioid analgesic for pharmacologic management of neonatal pain, with fentanyl as an effective alternative. Continuous or bolus epidural or IV infusion of opioids provides effective and safe pain control (Stork, 2006; Walden & Franck, 2003). Other methods of relieving pain are epidural/intrathecal infusion, local and regional nerve blocks, and topical anesthetics, as well as general anesthesia for surgery (Stork; Walden & Franck).

Parents are universally concerned that their infants are feeling pain during procedures. Nurses need to address these concerns and encourage the parents to speak with the health care professionals involved. Parents have the right to withhold consent for invasive procedures and are...
entitled to honest answers from those responsible for the infant's care. When appropriate, they also can help provide comfort measures for the infant. Kangaroo care is one method of parental intervention that comforts and calms the infant.

Parents want to know that nurses recognize pain in their infants and that the infants will be comfortable when they, the parents, are not present. They want to know that the nurse will advocate for comfort care for their baby. Although pain is considered a fifth vital sign, it cannot be assessed only at the time of vital signs. It must receive an ongoing evaluation of the pain level and the effectiveness of comfort measures used. This assessment is not lengthy but can be as simple as walking to the bedside and really looking at the infant's color, posture, movements, and breathing. Pain is a real phenomenon that is preventable in many instances. Pain management is a standard of care, and it is considered unethical not to prevent and effectively treat pain. Another growing area of neonatal nursing is end-of-life and palliative care. Most of this care centers on pain management. Palliative care is really comfort care entitled to honest answers from those responsible for the infant’s care. When appropriate, they also can help provide comfort measures for the infant. Kangaroo care is one method of parental intervention that comforts and calms the infant.

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### Near-Term Infants

Near-term infants are those born between 34 and 37 weeks of gestation (Wang, Dorer, Fleming, & Catlin, 2004). Some literature defines near term as 35 to 37 weeks (Medoff-Cooper, Bakewell-Sachs, Buus-Frank, & Santa-Donato, 2005). In practice these infants are often thought of as functionally at term and are treated as such. They usually have normal Apgar scores. However, these infants are at increased risk for problems when compared to term infants. In a study comparing near-term and full-term infants on length of stay and medical problems encountered, Wang and associates found important differences in hospital courses and clinical outcomes. Almost one third of the near-term infants had respiratory distress, and discharge was delayed for many of those. The near-term infants experienced temperature instability; hypoglycemia and poor feeding necessitating intravenous therapy; jaundice; evaluation for sepsis three times as often as term infants, and treatment with antibiotics.

The Association of Women’s Health, Obstetric and Neonatal Nurses (AWHONN) announced an initiative in 2005 to build awareness of near-term infants and to improve their care (Medoff-Cooper et al., 2005). The Association listed five things that parents of near-term infants should know and observe for (What the parents of near-term infants need to know, 2005):

1. **Feeding.** Near-term infants need to be fed more often, since they eat less. They may also have difficulty coordinating sucking and swallowing. Breastfeeding may be more problematic and necessitate the assistance of a professional.

2. **Sleeping.** Near-term infants may be sleepier than term infants and may need to be awakened for feedings.

3. **Breathing.** Near-term infants may have had respiratory distress after birth and may be prone to respiratory problems.

4. **Temperature.** Since they have less body fat than term infants, near-term infants may have more difficulty regulating their temperatures.

5. **Infections and jaundice.** The immune systems of near-term infants are immature; thus they are more likely to experience infections. They are also more likely to have jaundice.

The goal of these efforts is to raise the awareness of health care providers to the risks associated with near-term birth and to match the care environment with the needs of the near-term infant (Medoff-Cooper et al., 2005).

### Postmature Infants

A pregnancy that is prolonged beyond 42 weeks is a post-term pregnancy, and the infant who is born is called postmature. Postmaturity can be associated with placental insufficiency, resulting in a fetus that has a wasted appearance (dysmaturity) at birth because of loss of subcutaneous fat and muscle mass. Meconium staining of the fingernails may be noted, and the hair and nails may be long. The skin may peel off. Not all postmature infants will show signs of dysmaturity; some will continue to grow in utero and be large at birth.

The perinatal mortality rate is significantly higher in the postmature fetus and neonate. One reason for this is that during labor and birth, the increased oxygen demands of the postmature fetus may not be met. Insufficient gas exchange in the postmature placenta also increases the likelihood of intrauterine hypoxia, which may result in the passage of meconium in utero, thereby increasing the risk for meconium aspiration syndrome (MAS). Of all the deaths that occur in postmature newborns, half occur during labor and birth, about one third occur before the onset of labor, and one sixth occur during the postpartum period.

**Meconium Aspiration Syndrome**

Meconium staining of the amniotic fluid can be indicative of nonreassuring fetal status, especially in a vertex presentation. It appears in 8% to 20% of all births. Many infants with meconium staining exhibit no signs of depression at birth; however, the presence of meconium in the amniotic fluid necessitates careful supervision of labor and close monitoring of fetal well-being. Use of amniocentesis has decreased some of the incidence of MAS (Yoder, Kirsch, Barth, & Gordon, 2002). This procedure thins any meconium particles that may be present in the amniotic fluid, thus decreasing the chance of thick meconium being aspirated at the time of birth. Because these infants are surfactant deficient, one method of prevention of MAS is to use surfactant lavages immediately after birth. The findings indicate that outcomes for these infants are better than those of their counterparts who received no surfactant lavages (i.e., they were weaned from mechanical ventilation...
quicker, had less full-blown MAS, and had better oxygenation patterns (Wiswell et al., 2002). Although this was a randomized multicenter trial, more research is needed.

The presence of a team skilled at neonatal resuscitation is required at the birth of any infant with meconium-stained amniotic fluid (Bloom, 2006). The hypopharynx of the infant of a baby born through meconium should be suctioned after birth of the head and before birth of the shoulders. Vigorous infants need no special handling (American Heart Association, 2006; Vain, Szyld, Prudent, Wiswell, Aguilar, & Vivas, 2004).

If the infant is very depressed and the meconium is not removed from the airway at birth, it can migrate down to the terminal airways, causing mechanical obstruction leading to MAS. It also is possible that the fetus aspirated meconium in utero. Such meconium aspiration can cause a chemical pneumonitis. These infants may develop persistent pulmonary hypertension of the newborn, further complicating their management.

Persistent Pulmonary Hypertension of the Newborn

The term persistent pulmonary hypertension of the newborn (PPHN) is applied to the combined findings of pulmonary hypertension, right-to-left shunting, and a structurally normal heart. PPHN may be either a single entity or the main component of MAS, congenital diaphragmatic hernia, RDS, hyperviscosity syndrome, or neonatal pneumonia or sepsis. PPHN also is called persistent fetal circulation (PFC) because the syndrome includes a reversion to fetal pathways for blood flow.

A brief review of the characteristics of fetal blood flow can help in the visualization of the problems with PPHN (see p. 321-322, Fig. 13-9). In utero, oxygen-rich blood leaves the placenta via the umbilical vein, goes through the ductus venosus, and enters the inferior vena cava. From there it empties into the right atrium and is mostly shunted across the foramen ovale to the left atrium, effectively bypassing the lungs. This blood enters the left ventricle, leaves via the aorta, and preferentially perfuses the carotid and coronary arteries. Thus the heart and brain receive the most oxygenated blood. Blood drains from the brain into the superior vena cava, reenters the right atrium, proceeds to the right ventricle, and exits via the main pulmonary artery. The lungs are a high-pressure circuit, needing only enough perfusion for growth and nutrition. The ductus arteriosus (connecting the main pulmonary artery and the aorta) is the path of least resistance for the blood leaving the right side of the fetal heart, shunting most of the cardiac output away from the lungs and toward the systemic system. This right-to-left shunting is the key to fetal circulation.

After birth, both the foramen ovale and the ductus arteriosus close in response to various biochemical processes, pressure changes within the heart, and dilation of the pulmonary vessels. This dilation allows virtually all of the cardiac output to enter the lungs, become oxygenated, and provide oxygen-rich blood to the tissues for normal metabolism. Any process that interferes with this transition from fetal to neonatal circulation may precipitate PPHN. PPHN characteristically proceeds into a downward spiral of exacerbating hypoxia and pulmonary vasoconstriction. Prompt recognition and aggressive intervention are required to reverse this process.

The infant with PPHN is typically born at term or after term and has tachycardia and cyanosis. Management depends on the underlying cause of the persistent pulmonary hypertension. The use of ECMO has improved the chances of survival in these infants (see earlier discussion); however, it is considered a very invasive procedure. Use of nitric oxide (NO) as a pharmacologic intervention has increased in the last few years with great success. NO acts as a vasodilator to decrease the pulmonary hypertension while increasing oxygenation (Zahka & Bengur, 2006). This therapy is proving to work well either alone or with high-frequency ventilation. Another pharmacologic treatment is use of exogenous surfactant, since some of these infants appear to be surfactant deficient. Use of environmental strategies such as decreasing adverse stimuli (excessive light and noise) to decrease stress is another area of ongoing research. This intervention is used in conjunction with other therapies.

Another mode of treatment for PPHN and other respiratory disorders of the newborn is high-frequency ventilation, a group of assisted ventilation methods that deliver small volumes of gas at high frequencies and limit the development of high airway pressure, thus reducing barotrauma. High-frequency ventilation decreases carbon dioxide while increasing oxygenation. It can be effectively used in conjunction with NO (Zahka & Bengur, 2006). It is important to understand that PPHN is considered a cardiovascular and a respiratory problem. The lungs of these infants are healthy, but the hypertension of the cardiovascular system leads to their oxygenation problems.

COLLABORATIVE CARE

To ensure the safe birth of the fetus, it becomes important to determine whether the pregnancy is actually prolonged and also whether there is any evidence of fetal jeopardy as a result.

Most postmature infants are oversized but otherwise normal, with advanced development and bone age. A postmature infant will have some, but not necessarily all, of the following physical characteristics:

- Generally a normal skull, but the reduced dimensions of the rest of the body in the presence of dysmaturity make the skull look inordinately large
- Dry, cracked (desquamating), parchment-like skin at birth
- Hard nails extending beyond the fingertips
- Profuse scalp hair
- Depleted subcutaneous fat layers, leaving the skin loose and giving the infant an “old person” appearance
- Long and thin body
• Absent vernix
• Often meconium staining (golden yellow to green) of skin, nails, and cord, indicative of a hypoxic episode in utero or a perinatal infection such as listeriosis
• May have an alert, wide-eyed appearance symptomatic of chronic intrauterine hypoxia

Possible nursing diagnoses for the postmature infant include the following:

- **Impaired gas exchange related to**
  - decreased number of functional alveoli
  - deficiency of surfactant
  - cardiovascular hypertension in the pulmonary tree
- **Ineffective breathing pattern related to**
  - inadequate chest expansion, secondary to infant position
  - environmental stimuli
  - pain
  - pulmonary hypertension
- **Ineffective thermoregulation related to**
  - immature thermoregulation center
  - exposure to cold air or increased factors promoting thermal loss
  - lack of subcutaneous tissue and fat stores
- **Risk for infection related to**
  - invasive procedures
  - decreased immune response
  - immature skin or very thin, friable skin
- **Anxiety (parental) related to**
  - lack of knowledge regarding infant condition
  - lack of knowledge regarding infant cues
  - fear of death of infant
  - feeling powerless in the situation/ inability to protect infant from harm
- **Anticipatory grieving (parental) related to**
  - fear of infant’s death
  - lack of knowledge about what to expect
  - lack of clear communication on part of health care team

Immediate outcomes of care are that the postmature newborn will do the following:

- Initiate and maintain respiration.
- Experience no CNS trauma or infection.
- Have any birth trauma identified and treated promptly without sequelae.

The long-term expected outcome is that the infant will not experience adverse effects of postmaturity.

The immediate care rendered to postmature infants is similar to that given to preterm infants. Potential complications experienced by postmature infants include polycythemia, hypothermia, hypoglycemia, and meconium aspiration. See other sections for the management and care of infants with these complications.

The nurse can be assured that care was effective when the short-term outcomes for care have been achieved. Long-term follow-up will be needed to evaluate whether any adverse effects are a result of postmaturity.

### Other Problems Related to Gestation

#### Small for Gestational Age and Intrauterine Growth Restriction

Infants who are small for gestational age (SGA; e.g., weight is below the 10th percentile expected at term) and infants who have IUGR (rate of growth does not meet expected growth pattern) are considered high risk, with the perinatal mortality rate 5 to 20 times greater than that for the normal term infant (Kliegman, 2006). In some cases, a genetic linkage is possible, since maternal genes have been implicated when the incidence of infants who are SGA runs in families. The maternal genes must regulate the fetal growth potential through uteroplacental circulation effects (Kliegman). Women with chronic illness or suboptimal nutrition also are at risk for producing an SGA infant, since the nutrients to the fetus are diminished. Thus, although the underlying cause of the SGA circumstance can affect the condition of the infant, common problems that affect SGA and IUGR infants are predictable: perinatal asphyxia, meconium aspiration, hypoglycemia, polycythemia, and heat loss.

#### Perinatal Asphyxia

Commonly, IUGR infants have been exposed to chronic hypoxia for varying periods before labor and birth. Labor is a stressor to the normal fetus, but it is an even greater stressor for the growth-restricted fetus. The chronically hypoxic infant is severely compromised even by a normal labor and has difficulty compensating after birth. Appropriate management and resuscitation are essential for these depressed infants.

The birth of SGA babies with perinatal asphyxia may be associated with a maternal history of heavy cigarette smoking; preeclampsia; low socioeconomic status; multifetal gestation; gestational infections such as rubella, cytomegalovirus, and toxoplasmosis; advanced diabetes mellitus; and cardiac problems. The nursing staff must be alert to and prepared for possible perinatal asphyxia during the birth of an infant to a woman with such a history. Sequelae to perinatal asphyxia include MAS and hypoglycemia.

#### Hypoglycemia

All stressed infants are at risk for the development of hypoglycemia. Such stress may include perinatal asphyxia and IUGR. The definition of hypoglycemia differs for the term and the preterm infant. Hypoglycemia occurring within the first 3 days of life in the term infant is defined as a blood glucose level of less than 40 mg/dl; that occurring in the preterm infant within the same time frame is defined as a blood glucose level of less than 25 mg/dl. Symptoms of hypoglycemia include poor feeding, hypothermia, and diaphoresis. CNS symptoms can include tremors and jitteriness, weak cry, lethargy, floppy posture, convulsions, or coma. Diagnosis is confirmed by blood glucose determinations performed by the laboratory, when suspected, or by unit visual methods with reagent strips such as Chemstrip-BG or Dextrostix (Kliegman, 2006).
Polycythemia

Polycythemia or hyperviscosity of the blood is another common problem of the SGA infant. The plasma volume may be on average 52 ml/kg (normal, 43 ml/kg) (Kliegman, 2006). This condition results from the increased number of fetal oxygen cells to provide oxygen to the developing fetus. This can compromise blood circulation and oxygenation, and lead to further hypoglycemia and hypoxia in extrauterine life. A partial exchange transfusion may be necessary to reduce the viscosity of the blood.

Heat Loss

For numerous reasons, SGA infants are particularly susceptible to temperature instability, and close attention must be paid to maintain thermoneutrality for them. They have less muscle mass, less brown fat, less heat-preserving subcutaneous fat, and little ability to control skin capillaries. Nursing considerations in these infants focus on the maintenance of thermoneutrality to promote recovery from perinatal asphyxia, since cold stress jeopardizes such recovery (Kliegman, 2006).

COLLABORATIVE CARE

Several physical findings are characteristic of the SGA neonate:

- Generally a normal skull, but the reduced dimensions of the rest of the body make the skull look inordinately large
- Reduced subcutaneous fat stores
- Loose and dry skin
- Diminished muscle mass, especially over buttocks and cheeks
- Sunken abdomen (scaphoid) as opposed to the well-rounded abdomen seen in normal infants
- Thin, yellowish, dry, and dull umbilical cord (normal cord is gray, glistening, round, and moist)
- Sparse scalp hair
- Wide skull sutures (inadequate bone growth)

The nursing care given to the SGA infant is determined by the nature of the clinical problems and is the same as that given to the preterm infant with the same problems. Maintaining a clear airway and preventing cold stress support gas exchange. Hypoglycemia is treated with oral feedings (e.g., breast milk, formula, dextrose solution) per the hospital protocol. Parenteral infusions may be necessary. If polycythemia is present, assessment of the cardiovascular circulation is important, and assistance with a partial exchange transfusion may be necessary. To assist with thermoregulation, an external heat source (radiant warmer or incubator) is used until the infant’s temperature is stabilized. The nursing support given to parents is similar to that given to parents of preterm infants.

Large for Gestational Age

The large for gestational age (LGA), or oversized, infant traditionally has been regarded as one weighing 4000 g or more at birth. An infant is considered LGA at any gestation when the weight is above the 90th percentile on growth charts or two standard deviations above the mean weight for gestational age. Certain fetal disorders also can result in LGA infants. These include transposition of the great vessels and Beckwith-Wiedemann syndrome.

Birth trauma, especially in infants with a breech or shoulder presentation, is a serious hazard for the oversized neonate. Asphyxia or CNS injury, or both, may occur. All pregnancies of more than 42 weeks of gestation must be carefully evaluated. All large fetuses are monitored during a trial of labor, and preparation is made for cesarean birth if a nonreassuring fetal status or poor progress of labor occurs. LGA newborns may be preterm, term, or postterm; they may be the infants of mothers who are diabetic (or prediabetic); and they may be postmature. Each of these problems has special concerns. Regardless of any coexisting potential problems, the oversized infant is at risk just by virtue of its size.

DISCHARGE PLANNING

Discharge planning for the high risk infant begins at the time of admission. Throughout the infant’s hospitalization, the discharge planning coordinator gathers information from all of the health care team members. This information is used to determine the infant’s and family’s readiness for discharge. Nurses are very influential members of the planning team because as the direct caregivers throughout the infant’s hospitalization, they have a firsthand knowledge of the infant and the family.

As the home care needs of the infant’s parents are assessed, steps are taken to eliminate any knowledge deficits. Information is provided about infant care, especially as it pertains to the particular infant’s home needs (e.g., the administration of oxygen, gastrostomy feedings). Parent education includes having them give return demonstrations of their infant care skills to show whether they are becoming increasingly independent in the provision of this care. Parents also should obtain an age-appropriate car seat before the discharge of their infant. Instruction in infant CPR should be offered to all parents before discharge. With the emphasis on the American Academy of Pediatrics (AAP) Back-to-Sleep program to reduce the incidence of SIDS, it may be necessary to place the infant in the supine position before discharge to challenge the infant’s ability to tolerate this position. Because the parents saw their infant in a prone or side-lying position while sick; they need to understand the importance of use of the new positioning on the back once the infant is stable and at home.
Enriched Formula for Low-Birth-Weight Infants

BACKGROUND
- Preterm and low-birth-weight (LBW) (less than 2.5 kg) infants have fewer nutrient reserves than term babies, yet are more vulnerable to physiologic stresses that increase nutritional demands, such as respiratory distress, cold stress, or infection. Smaller infants may not be able to take in and process enough calories and protein to compensate for the deficit. Consequently, preterm and LBW infants remain growth restricted (below the 10th percentile for equivalent gestational age), sometimes for years. Nutritional deficiency has been linked with poor bone density, cardiovascular disease, insulin resistance, high blood pressure, and obesity in later life. Many hospitals start calorie- and protein-enriched formula for their smallest clients. Compared to breast milk, 100 ml of standard formula has 68 kcal and 1.4 to 1.5 g of protein, while preterm formula started in hospital may have 80 kcal and 2 to 2.4 g of protein. Infants are then sent home with formula that has 72 to 74 kcal and 1.8 g of protein per 100 ml. Some calorie-enriched formula is poorly tolerated as a result of decreased gastric motility.

OBJECTIVES
- The reviewers’ goal was to compare the growth and development of preterm and LBW infants fed standard versus enriched (at least 72 kcal and 1.6 g of protein per 100 ml) formula. They included exclusively formula-fed babies, as well as breastfed babies who were supplemented with enriched formula. Outcomes included weight, height, head circumference, neurodevelopmental outcomes on a validated scale, IQ, educational achievement, bone mineralization and growth, feed tolerance, and blood pressure.

METHODS
Search Strategy
- After a thorough search of the Cochrane Central Register of Controlled Trials and databases, conferences, and references, the authors identified six randomized or quasi-randomized controlled trials that were double-blinded. They were dated 1992 to 2004, representing 424 infants from Europe, Israel, and North America.

Statistical Analyses
- Similar data were pooled. Reviewers calculated relative risk for dichotomous (categoric) data, such as feeding intolerance, and weighted mean difference for continuous data, such as head circumference. Differences between groups outside the 95% confidence interval were accepted as significant.

FINDINGS
- At 18 months, there were no differences found between standard and enriched formula groups in weight or head circumference. There was a significant difference in height of 1 cm at 18 months, favoring the enriched formula. No differences were found in neurodevelopmental scores (Bayley Scales Mental Development Index and Psychomotor Development Index). Bone mineralization was similar. There were no differences in feed tolerance. Two studies reported that infants fed enriched formula drank less milk than the standard formula group. This caused their calorie intake to equalize, although the enriched group still received more protein.

LIMITATIONS
- There is still limited evidence as to the longer-term outcomes of linear growth and neurodevelopmental milestones. The studies are fairly small. There were some differences in the formulas and the other additives, such as minerals, that might also potentiate growth.

IMPLICATIONS FOR PRACTICE
- It does not appear that enriched formula is harmful, but there is limited evidence to recommend it for catch-up growth of the preterm or the LBW infant.

IMPLICATIONS FOR FURTHER RESEARCH
- Future research may establish whether outcomes at 18 months can predict longer-term outcomes. There were no trials measuring cognitive or educational levels, evidence of rickets, or blood pressure, or the longer-term metabolic or cardiovascular outcomes. Future research should address the possible combinations of minerals and vitamins with protein that can foster absorption and growth. Breastfeeding, alone or supplemented with some enrichment, should be included in any future discussion of infant feeding, since its advantages for vulnerable infants are well documented.

Refferrals for appropriate resources should be made whether the infant just needs follow-up or is going home to die. Social service involvement is especially important for young or psychosocially high risk parents (e.g., substance abusers or those with a mental illness). Social services also can provide parents with information about financial assistance (e.g., Temporary Assistance for Needy Families (TANF) (http://aspe.hhs.gov/hsp/abbrev/afdc-tanf.htm), Medicaid, Crippled Children’s Program, Social Security Disability). Appropriate genetic counseling, referral, and follow-up should be provided.

Infants with developmental disabilities, or those infants who may be at risk for further problems (preterm, infants), are referred to appropriate community programs. Federal Public Law 102-119 mandates that community resources be available to those children and families with special educational and medical needs (Robinson & Driscoll, 2003). Such services range from family counseling to physical therapy. Some hospitals also offer infant stimulation and development programs for the parents of at-risk infants. This law recognizes nursing as one of the 10 qualified disciplines that can provide these services. Federal Public Law 106-402 contains four grant programs to assist those with developmental disabilities to reach their maximum potential (www.acf.hhs.gov/programs/add/Factsheet.html).

Refferrals are made for home health assistance, as appropriate (some medical plans cover these services). These health care providers can perform actual nursing functions, as well as provide some relief from the emotional burden of caring for an infant with medical problems. Special attention should be given to parents’ feelings of uncertainty, anxiety, and overwhelming frustration. Parents often have these emotions during the planning for an infant’s home care, especially if the infant has had a severe or prolonged illness (Holditch-Davis, Bartlett et al., 2003; Miles et al., 2002).

TRANSPORT TO A REGIONAL CENTER

If a hospital is not equipped to care for a high risk mother and fetus or a high risk infant, transfer to a specialized perinatal or tertiary care center is arranged. Maternal transport ideally occurs with the fetus in utero because this has two distinct advantages: (1) The associated neonatal morbidity and mortality are decreased; and (2) infant-parent attachment is supported, thereby avoiding separation of the parents and infant.

For a variety of reasons, however, it is not always possible to transport the mother before the birth. These reasons include imminent birth and unanticipated problems; therefore, physicians and nurses in level 1 and 2 facilities must have the skills and equipment necessary for making an accurate diagnosis and implementing emergency interventions to stabilize the infant’s condition until transport can occur (Box 40-8) (Pettett, Pallotto, & Merenstein, 2006). The goal of these interventions is to maintain the infant’s condition within the normal physiologic range. Specific attention is given to the following areas:

- Vital signs
- Oxygen and ventilation
- Thermoregulation
- Acid-base balance
- Fluid and electrolyte levels
- Glucose level
- Developmental interventions

The transport team may consist of physicians, nurse practitioners, nurses, and respiratory therapists. Commonly the team consists of a nurse trained in neonatal intensive care and a respiratory therapist. The team must have expertise in resuscitation, stabilization, and provision of critical care during the transport which can occur on the ground or in the air (Fig. 40-16, B). In a neonatal transport, the team should provide information for the parents about the tertiary center (Box 40-9). Transport teams can integrate an individual developmental plan of care into their caregiving efforts, thereby initiating multidisciplinary interventions early in the infant’s life.

The birth of any high risk infant can cause profound parental stress. Parents can grieve the loss of the ideal infant. They are fearful of the possible eventual outcomes for the infant. They also must deal with the technological world surrounding their infant, and amid all the equipment, it is sometimes difficult for them to perceive the infant and respond to its needs. Parents of high risk infants who have been transported to regional centers therefore need special support. As one way to deal with this problem, many intensive care units provide the family with a handbook or pictures of the tertiary care unit to help them understand what is going on around them. Parents should have the name and telephone number of a contact person at the regional center.

TRANSPORT FROM A REGIONAL CENTER

Infants may need to be transferred back to the referring facility. Often preterm infants who require thermoregulation and gavage feedings can be cared for in community hospitals closer to the parents’ home. This back transfer allows parents to visit their infant more easily and to work with their personal health care provider on the long-range expected outcomes for the infant. Specialized incubators make these trips possible (see Fig. 40-16, A). However, parents may express mixed feelings about such return transports and may be reluctant to adapt to a different facility and group of caregivers. To minimize some of these concerns, it is important to give the parents very clear information about return transports during the initial discharge planning.

Although at the time of discharge, parents may not recognize the need for information on the various resources available to help them in the care of their infant, they can be given such lists of agencies and telephone numbers for later use. Providing them with a client-specific directory...
### Neonatal Resuscitation Supplies and Equipment

**SUCTION EQUIPMENT**
- Bulb syringe
- Mechanical suction and tubing
- Suction catheters, 5F or 6F, 8F, 10F, 12F or 14F
- 8F feeding tube and 20 ml syringe
- Meconium aspirator

**BAG-AND-MASK EQUIPMENT**
- Device for delivering positive-pressure ventilation, capable of delivering 90% to 100%
- Face masks, newborn and premature sizes (cushioned-rim masks preferred)
- Oxygen source with flowmeter (flow rate up to 10 L/min) and tubing

**INTUBATION EQUIPMENT**
- Laryngoscope with straight blades, No. 0 (preterm) and No. 1 (term)
- Extra bulbs and batteries for laryngoscope
- Endotracheal tubes, 2.5-, 3, 3.5-, 4-mm internal diameter (ID)
- Stylet (optional)
- Scissors
- Tape or securing device for endotracheal tube
- Alcohol sponges
- CO₂ detector or capnograph
- Laryngeal mask airway (optional)

**MEDICATIONS**
- Epinephrine, 1:10,000 (0.1 mg/ml): 3 ml or 10 ml ampules
- Isotonic crystalloid (normal saline or Ringer’s lactate) for volume expansion: 100 or 250 ml
- Sodium bicarbonate, 4.2% (5 mEq/10 ml): 10 ml ampules
- Naloxone hydrochloride, 0.4 mg/ml: 1-ml ampules; or 1.0 mg/ml: 2-ml ampules
- Dextrose, 10%: 250 ml
- Normal saline for flushes
- Umbilical vessel catheterization supplies
- Sterile gloves
- Scalpel or scissors
- Antiseptic prep solution
- Umbilical tape
- Umbilical catheters, 3.5F, 5F
- Three-way stopcock
- Syringes: 1, 3, 5, 10, 20, 50 ml
- Needles: 25-, 21-, 18-gauge, or puncture device for needleless system

**MISCELLANEOUS**
- Gloves and appropriate personal protection
- Radiant warmer or other heat source
- Firm, padded resuscitation surface
- Clock with second hand (timer optional)
- Warmed linens
- Stethoscope (neonatal head preferred)
- Tape, ½- or ¾- inch
- Cardiac monitor and electrodes or pulse oximeter and probe (optional for delivery room)
- Oropharyngeal airways (0, 00, and 000 sizes or 30, 40, and 50-mm lengths)

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**FIG. 40-16**

A, Total life support system for transport of high risk newborns. B, Life Flight helicopter to transport infant. (A, Courtesy UNC Hospitals, Carolina Air Care, Chapel Hill, NC. B, Courtesy OSF St. Francis Medical Center, Peoria, IL.)

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covering special programs, social support, community, and funding resources can help them make the transition to the home care of their infants. As the nurse continually reinforces the idea that the infant will go home, this will prompt the parents to plan for the days ahead and therefore be ready to take their infant home when the time comes.

ANTICIPATORY GRIEF

Families experience anticipatory grief when they are told of the impending death of their infant. Anticipatory grief prepares and protects parents who are facing a loss. Parents who have an infant with a debilitating disease (with or without a congenital deformity), but one that may not necessarily threaten the life of the child, also may experience anticipatory grief. An alteration in relationships, a change in lifestyle, and a very real threat to their hopes and dreams for the future may affect the day-to-day interaction of the family with their infant and the staff. Nurses can help facilitate the family’s grieving process. If the nurse observes that a family member’s day-to-day interactions with the infant change, the nurse should assess the situation and request psychosocial support or intervention by a chaplain or social worker, if necessary.

Loss of an Infant

Parents who know their infant is going to die have a very difficult time. Before the infant’s death, the parents need to direct their attention, energy, and caregiving activities toward the dying infant. However, some parents find it difficult to visit their infant even for short periods once a terminal diagnosis has been made. Grandparents also grieve but often are unsure how to comfort their own child (the infant’s parent) during the period of impending death. Health care professionals can help by involving the family in the infant’s care, providing privacy, answering questions, and preparing them for the inevitability of the death (see Chapter 41). Today there is a growing emphasis on hospice and palliative care for infants and their families (End-of-Life Nursing Education Consortium (ELNEC), 2005).

The nursing staff also experiences grief. Many primary staff nurses find themselves grieving as if the infant were their own because they often have been the health professional that has worked closely with the infant and family for weeks, or even months. Managers and other staff members must acknowledge this grief. Talking about the infant or attending the funeral may help the affected staff members resolve their feelings about the infant’s death (ELNEC, 2005).

key points

- Preterm infants are at risk for problems stemming from the immaturity of their organ systems.
- Nurses who work with preterm and other high risk infants observe them for respiratory distress and other early symptoms of physiologic disorders.
- The adaptation of parents to preterm or high risk infants differs from that of parents to normal term infants.
- Nurses can facilitate the development of a positive parent-child relationship.
- Nurses’ skills in interpreting data, making decisions, and initiating therapy in newborn intensive care units are crucial to ensuring infants’ survival.
- Pain management requires vigilant ongoing assessment, anticipation of painful events, and early interventions to prevent and diminish such a response.
- Nurses need to assess the macroenvironments and microenvironments of the infant and family to create a developmentally positive atmosphere.
- Developmental care is a philosophy that embraces family-centered care and awareness of the impact of environmental stimuli on the physical and psychologic well-being of the infant and family.
- Parents need special instruction (e.g., CPR, oxygen therapy, suctioning, developmental care) before they take home a high risk infant.
- SGA infants are considered at risk because of fetal growth restriction.
- The high incidence of nonreassuring fetal status among postmature infants is related to the progressive placental insufficiency that can occur in a postterm pregnancy.
- Specially trained nurses may transport high risk infants to the home care of their infants. As the nurse continues to reinforce the idea that the infant will go home, this will prompt the parents to plan for the days ahead and therefore be ready to take their infant home when the time comes.
- Any particular rules or regulations regarding the special care unit
- Location of parking facilities, nearby lodging, and rules regarding young children (siblings)
- Any particular rules or regulations regarding the special care unit
- Names of individuals likely to be involved with the baby’s care
- Information of the special care unit—what it is, what it does
- Visiting hours and hospital rules
- Telephone numbers
- Exact location of the unit—address, map


About the Tertiary Center

Access the website of your local and state health department. What services are available for parents of high risk infants? Are follow-up clinics available? Are there groups for parents of high risk infants? What parent education materials are available? Is there an active local chapter of AWHONN?
REFERENCES


