Medical Considerations and Practice Guidelines for the Neonatal Occupational Therapist

Jan Hunter, Jan Mullen, Dara Varga Dallas

Key Words: infant, high risk infant, low birth weight

Provision of safe and effective occupational therapy in neonatal intensive care units requires an understanding of neonatal medical conditions and treatment modalities. This article explains basic medical concepts and technology with terminology frequently encountered in neonatal intensive care. Discussions of neonatal thermoregulation, respiratory care, hemodynamic monitoring, and metabolic support are presented as general areas of focus. Equipment usage and precautions are included. Several case studies illustrate the incorporation of medical knowledge into neonatal occupational therapy practice.

The neonatal intensive care unit (NICU) is an intense environment where highly trained professionals use sophisticated medical procedures and technology to treat fragile infants and try to provide support for their often stressed families. As advances in care and technology continue to save smaller and sicker infants, concerns about the developmental implications and sequelae of neonatal intensive care have emerged (Collin, Halsey, & Anderson, 1991; Luchi, Bennett, & Jackson, 1991; Saigal, Szatmari, Rosenbaum, Campbell, & King, 1991). Research and recent literature support the concept of developmentally supportive care in the NICU as beneficial and desirable (Als et al., 1986; Becker, Grunwald, Moorman, & Stuhr, 1991; Lefrak-Okikawa & Lund, 1993; VandenBerg, 1990). Although this developmental awareness explains the involvement and acceptance of occupational therapists in neonatal units, adequate advance preparation essential to the provision of knowledgeable, safe, and effective therapy services is frequently lacking.

The neonatal intensive care unit is considered an advanced area of practice that requires specific knowledge and skills; neither entry-level education nor specialization in general pediatrics provides the extensive knowledge and skills necessary for provision of therapy services in the NICU (American Occupational Therapy Association [AOTA], 1993; Scull & Dietz, 1989; Sweeney & Chandler, 1990; VandenBerg, 1993). Risks to medically fragile neonates are profoundly increased when therapists have insufficient experience and training (Sweeney & Chandler, 1990).

There has been a proliferation of literature and resources in the area of neonatal developmental intervention (Creger, 1989; Sells, 1992; Vergara, 1993; Wyly & Allen, 1990), but comprehensive neonatal medical information has not been equally emphasized in publications commonly read by occupational therapists. This article highlights some of the basic medical knowledge and terminology necessary to provide a beginning foundation for understanding neonatal medical management. Thermoregulation, respiratory care, and metabolic–hemodynamic support are reviewed and case studies demonstrate how this information affects and directs occupational therapy practice.

Neonatal Thermoregulation

Although specific approaches may vary among hospitals and physicians, the establishment and maintenance of an optimal thermal environment for small and sick infants are always medical priorities in neonatal intensive care. Understanding terminology, the mechanics of heat balance, and consequences of thermal imbalance in high-risk neonates suggests practice guidelines for the occupational therapist.

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Thermoregulation is the ability to maintain a stable body temperature. Thermoregulation implies the ability to increase production and conservation of heat in a cold environment and the ability to reduce heat production with more rapid heat dissipation in too warm an environment (Klaus, Fanaroff, & Martin, 1993; Perlstein, 1992).

The process of heat production is called thermogenesis. Neonates cannot shiver sufficiently for heat production and must rely solely on metabolism (nonshivering thermogenesis) to maintain a stable body temperature (Blake & Murray, 1999). Thermogenesis in newborns is related to the specialized brown fat that develops during the last trimester primarily around the nape of the neck, in the axilla, and between the scapulae. Infants born after 30 weeks gestation are better able to produce heat on demand and to maintain a stable temperature than are infants born at 30 weeks’ gestation or less (Korones, 1986).

Sick or small preterm neonates have difficulty maintaining a stable body temperature. A disproportional amount of heat is lost to the environment, as extended postures result in a large area of exposed body surface per kilogram of body weight, and as the small depth of the infant’s body, with thin skin and inadequate subcutaneous fat, facilitates heat transfer from deep within the body to skin and air. Pulmonary dysfunction with impaired oxygen use may compromise heat-producing metabolism. Central nervous system immaturity and frequent caregiving interventions may also interfere with maintenance of a stable body temperature (Mok, Bass, Ducker, & McIntosh, 1991).

Mechanics of Heat Loss

The difference between deep body core temperature and skin surface temperature is called the internal thermal gradient; heat transfers from the warmer core to the cooler skin. The external thermal gradient refers to the difference between skin surface temperature and environmental temperature; heat is transferred between the infant and the surrounding environment by convection, conduction, radiation, and evaporation (Blake & Murray, 1993; Korones, 1986) (see Table 1).

Heat Balance

Heat balance is achieved when heat produced from the infant’s metabolic activity, heat lost from the infant’s body, and heat supplied from external sources reach a state of equilibrium. Critical temperature is the temperature below which a metabolic response to cold is necessary to replace lost heat; this means the infant must consume more oxygen and use growth calories to generate warmth. A neutral thermal environment (NTE) is the narrow range of environmental temperatures in which the infant can maintain a normal body temperature with minimal metabolic effort and thus minimal oxygen use (Blake & Murray, 1993). Because preterm babies tend to lose more heat than they generate, caregivers must minimize heat loss and provide additional heat from the environment.

Exposure to cold is the most frequent thermoregulation problem in neonatal units. Hypothermia, or abnormally low body temperature, is commonly associated with extremely low birth weight after resuscitation of asphyxiated premature infants, or may be an early sign of sepsis or intracranial pathology. A drop in body core temperature occurs when the infant is no longer able to compensate for prolonged or severe cold stress. Hypothermia can quickly lead to cold stress; severe cold stress can result in death (see Table 2).

Hyperthermia, or an increase in body core temperature, may reflect excessive environmental heat, infection, dehydration, disturbed central nervous system thermal regulation, or mismanaged or neglected equipment (Klaus et al., 1993). Most infants in an inappropriately warm environment can dissipate heat effectively. Subtle

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Types of Heat Loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>Definition</td>
</tr>
<tr>
<td>Convection</td>
<td>Heat transferred from the infant’s body surface to cooler surrounding air</td>
</tr>
<tr>
<td>Conduction</td>
<td>Heat transferred when the infant’s body is in direct contact with a cooler solid object, such as a baby scale or caregiver’s hand</td>
</tr>
<tr>
<td>Radiation</td>
<td>Heat transferred from the infant’s body to cooler solid surfaces in the environment that are not in direct contact with the infant, such as walls of the incubator</td>
</tr>
<tr>
<td>Evaporation</td>
<td>Heat loss that occurs when liquid from the infant’s respiratory tract and immature permeable skin is converted into a vapor. Evaporation is a major source of heat and water loss in a tiny neonate</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 2</th>
<th>Symptoms of Neonatal Cold Stress</th>
</tr>
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<tbody>
<tr>
<td>Symptom</td>
<td>Description</td>
</tr>
<tr>
<td>Temperature</td>
<td>Skin temperature less than 36°C (96.8°F); rectal or axillary temperature less than 36.5°C (97.7°F)</td>
</tr>
<tr>
<td>Behavior</td>
<td>Poor feeding, irritability, lethargy, difficulty to arouse; decreased muscle tone; central nervous system depression</td>
</tr>
<tr>
<td>Appearance</td>
<td>Feels cold to the touch (especially peripherally); bright red skin color; cyanosis or pallor; edema of the extremities and face, progressing to sclerema; abdominal distention</td>
</tr>
<tr>
<td>Respiratory</td>
<td>Hypoventilation; slow, shallow, irregular pattern, often with an expiratory grunt; apnea and bradycardia</td>
</tr>
<tr>
<td>Metabolic</td>
<td>Metabolic acidosis, hypoglycemia, hyperkalemia, elevated blood urea nitrogen, oliguria</td>
</tr>
</tbody>
</table>
Radiant Warmer

An incubator is a clear plastic heated box enclosing the infant to decrease oxygen requirements and facilitate thermal regulation. Incubators are used for premature infants, especially those born between 26 and 32 weeks of gestation, to maintain a neutral thermal environment while the infant is in the crib. An infant in an open crib is generally larger and medically more stable. Hats, clothes, socks, and blankets are used to maintain a neutral thermal environment while the infant is in the crib. When the infant is out of the crib, continued swaddling is important to maintain body heat.

Respiratory Diseases

Respiratory diseases and their complications are the most common causes of neonatal morbidity and mortality encountered in the NICU. Respiratory distress syndrome (RDS), or hyaline membrane disease, is an acute lung disease primarily affecting preterm infants, in which the lungs cannot inflate or function correctly because of a lack of surfactant. RDS remains the most common cause of respiratory distress among preterm infants, affecting 10% to 15% of infants weighing less than 2500 g (Fanaroff & Martin, 1992). Although RDS refers to specific pulmonary pathology, respiratory distress symptoms (tachypnea, grunting, nasal flaring, chest retractions, apnea, cyanosis) may result from both pulmonary and nonpulmonary causes (Corbett, 1990; Fanaroff & Martin, 1992; Walsh, Carlo, & Miller, 1988) (see Table 3). Treatment for respiratory distress can be complex. The underlying etiology must be addressed, such as surfactant therapy in RDS or repair of a diaphragmatic hernia. General supportive measures may include thermoregulation, fluids, nutrition, diuretics, positioning, and chest physical therapy. In addition, oxygen therapy may be necessary with or without assisted ventilation. Because of the real danger of iatrogenic damage to the infant from indiscriminate use of supplemental oxygen and assisted ventilation, each infant is carefully assessed and monitored with respiratory monitoring.
Table 3
Etiologies of Respiratory Distress and Respiratory Failure

<table>
<thead>
<tr>
<th>Pulmonary</th>
<th>Nonpulmonary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pulmonary insufficiency of the preterm infant</td>
<td>Diaphragmatic hernia with secondary lung hypoplasia</td>
</tr>
<tr>
<td>Transient tachypnea of the newborn</td>
<td>Persistent pulmonary hypertension</td>
</tr>
<tr>
<td>Lack of surfactant with resultant RDS</td>
<td>Congenital heart failure</td>
</tr>
<tr>
<td>Primary pulmonary hypoplasia, i.e., due to chest compression from severe oligohydramnios</td>
<td>Effusions/chylothorax</td>
</tr>
<tr>
<td>Aspiration syndromes</td>
<td>Intrathoracic tumors/cysts</td>
</tr>
<tr>
<td>Atelectasis</td>
<td>Upper airway obstruction (i.e., choanal atresia, Pierre-Robin sequence, macroglossia, cystic hygroma, subglottic stenosis, tracheal stenosis, laryngomalacia, tracheoesophageal fistula, positioning)</td>
</tr>
<tr>
<td>Air leaks</td>
<td>CNS causes (i.e., asphyxia, IVH, apnea)</td>
</tr>
<tr>
<td>Pulmonary edema</td>
<td>Musculoskeletal (i.e., Werdnig-Hoffman syndrome, phrenic nerve)</td>
</tr>
<tr>
<td>Pneumonia</td>
<td>Metabolic imbalance (acidosis, hypoglycemia)</td>
</tr>
<tr>
<td>Pulmonary hemorrhage</td>
<td>Hematologic (polycythemia, anemia)</td>
</tr>
<tr>
<td>Chronic lung disease, i.e., bronchopulmonary dysplasia</td>
<td></td>
</tr>
<tr>
<td>Wilson-Mikity syndrome</td>
<td></td>
</tr>
</tbody>
</table>

Note. RDS = respiratory distress syndrome, CNS = central nervous system, IVH = intraventricular hemorrhage.

Oxygen Therapy Without Assisted Ventilation

Supplemental oxygen may be provided without ventilatory assistance for infants who are breathing adequately on their own but who need a higher concentration of oxygen than is contained in room air. Warm, humidified oxygen at the desired concentration can be delivered to the Airways and lungs via an oxygen hood (oxyhood) placed over the infant's head. An oxygen analyzer is also placed under the hood to verify the percent of oxygen delivered; oxygen flow rates are adjusted (approximately 4 to 8 L per minute) to prevent accumulation of carbon dioxide.

Nasal cannulas can be used to deliver supplemental humidified oxygen via a flexible plastic cannula with a flow directed into the nares. Only low-flow oxygen (≤1 L per minute) should be administered, as high oxygen flow can dry and irritate nasal mucosa and may cause the infant to experience gas with resultant regurgitation. Even when set at 100%, the maximum oxygen available is only around 40%, because the infant breathes in faster than the flow of oxygen and also inhales room air around the nasal prongs, thus the oxygen concentration becomes diluted. Nasal cannulas are often used for infants requiring low concentrations of supplemental oxygen (22% to 30%) and in infants requiring extended oxygen therapy.

Oxygen Therapy With Assisted Ventilation

Assisted ventilation refers to moving gas into and out of the lungs with an external source connected directly to the patient (Goldsmith & Karotkin, 1988). The external source may be a resuscitation bag, a continuous distending pressure device, or a mechanical ventilator. Common attachments to the infant include a face mask, nasal prongs, endotracheal tube, or tracheostomy tube. The purposes of assisted ventilation are to provide alveolar ventilation, carbon dioxide removal, and adequate oxygenation, and to reduce the infant's work of breathing. The actual practice of assisted ventilation is extremely complex, depends on each infant's specific problems, and varies widely among centers. Many infants will need more than one form of assisted ventilation over the course of their hospital stay (see Table 4). Familiarity with relevant basic terminology (see Table 5) facilitates understanding of assisted ventilation; this terminology is included in some of the case studies at the end of this article.

Two methods of mechanical ventilation are conventional and high-frequency ventilation; each method may use various types of ventilators on the basis of different operating principles. Conventional ventilation is the more commonly used method and is based on principles of traditional pulmonary mechanics (Wung, 1993) (see Table 6).

High-frequency ventilation refers to several new modes of mechanical ventilation that deliver small volumes of gas at high frequencies and limit the development of high airway pressures (barotrauma) that may contribute to iatrogenic lung damage. High-frequency ventilation appears to be promising in the treatment of severe pulmonary failure that is complicated by air leaks; in some instances, it can provide adequate ventilation to patients with poor lung compliance despite lower airway pressures than are generated with conventional mechanical ventilation. High-frequency ventilation, as a relatively new technology that is still being developed and perfected, is not available in all NICUs (Carlo & Chatburn, 1988; Fanaroff & Martin, 1992).

Another relatively new technology that is not widely available is extracorporeal membrane oxygenation (ECMO). ECMO is a sophisticated life support system that uses modified cardiopulmonary bypass to provide nearly total lung rest and to minimize iatrogenic complications of barotrauma for qualifying infants in neonatal respiratory failure who are unresponsive to conventional medical treatment.
In addition to work during oxygen therapy, arterial oxygen partial pressure (PaO₂) can be continuously measured by incorporating an oxygen electrode into the tip of a catheter inserted into the umbilical artery. This intravascular electrode allows for PaO₂ monitoring continuously while minimizing the need for frequent arterial blood sampling. School-age sequelae are still under investigation (Thompson & Perlman, 1993). Management. It may also be useful for perioperative support during cardiac surgery. From a population meeting the criteria for at least an 80% risk of death, more than 80% survive with ECMO and most do well developmentally. School-age sequelae are still under investigation (Thompson & Perlman, 1993).

### Monitoring During Therapy

In addition to physical assessment and appropriate laboratory work during oxygen therapy, arterial oxygen partial pressure (PaO₂) can be continuously measured by incorporating an oxygen electrode into the tip of a catheter inserted into the umbilical artery. This intravascular electrode allows for PaO₂ monitoring continuously while minimizing the need for frequent arterial blood sampling.

### Table 4 Assisted Ventilation

<table>
<thead>
<tr>
<th>Method</th>
<th>Operating Principle</th>
<th>Use</th>
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<tbody>
<tr>
<td>Bag and mask ventilation</td>
<td>Assists the infant's breathing by delivering positive pressure and oxygen via a face mask, thereby avoiding endotracheal intubation</td>
<td>Useful during resuscitation at delivery or of a depressed infant, and for infants with intermittent apnea. Effective for short-term use, but impractical for prolonged ventilatory assistance</td>
</tr>
<tr>
<td>Continuous positive airway pressure (CPAP)</td>
<td>Application of a steady stream of pressurized air to the airways and alveoli throughout the respiratory cycle when the patient breathes spontaneously. It can be used with or without supplemental oxygen, and can be delivered using a nasopharyngeal tube (NPCPAP), or endotracheal tube (CPAP).</td>
<td>Useful in the course of treatment for RDS and pulmonary edema, and especially useful for apnea. Infants are often placed on nasal CPAP before intubation and mechanical ventilation, or on endotracheal CPAP before extubation.</td>
</tr>
<tr>
<td>Mechanical ventilation</td>
<td>Involves the use of mechanical work to inflate the lungs, increase alveolar ventilation, and improve gas exchange by controlling or assisting ventilation. It can provide a measured amount of FiO₂ to the lungs and can prevent alveolar collapse by the use of continuous distending or positive pressure. The PIP, PEEP, FiO₂, and rate (IMV) can be adjusted for the infant's changing needs.</td>
<td>Some indications for mechanical ventilation include marked retractions and frequent apnea on nasal CPAP, PaO₂ &lt; 50 mmHg with an FiO₂ 80% to 100%, PaCO₂ &gt; 65 mmHg, or intractable respiratory acidosis with pH &lt; 7.2–7.5.</td>
</tr>
</tbody>
</table>

CPAP = continuous positive airway pressure, RDS = respiratory distress syndrome, NPCPAP = nasopharyngeal CPAP, PaO₂ = arterial oxygen partial pressure, PIP = peak inspiratory pressure, FiO₂ = fraction of inspired air, PEEP = positive end expiratory pressure, IMV = intermittent mandatory ventilation.

Pulse oximetry is a noninvasive method that allows continuous measurement of arterial oxygen content in hemoglobin. A probe is wrapped around a body part (usually the infant's thumb, toe, or foot). A beam of infrared and red light is emitted that is picked up by a sensor positioned opposite the light source; the intensity of the light picked up by the sensor is related to the percentage of oxygen delivered per breath. Room air is 21%.

### Table 5 Terminology Related to Respiratory Care and Assisted Ventilation

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
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</thead>
<tbody>
<tr>
<td>Peak inspiratory pressure (PIP)</td>
<td>Peak pressure delivered to proximal airways during a ventilator breath</td>
</tr>
<tr>
<td>Positive end expiratory pressure (PEEP)</td>
<td>Positive pressure applied to the alveoli and the airways during expiration when the patient is breathing with a mechanical ventilator; PEEP increases the FRC and decreases the potential for collapse of the alveoli</td>
</tr>
<tr>
<td>Continuous positive airway pressure (CPAP)</td>
<td>Positive pressure applied to the alveoli and the airways throughout the respiratory cycle when the patient is breathing with a mechanical ventilator</td>
</tr>
<tr>
<td>Intermittent mandatory ventilation (IMV)</td>
<td>The ventilator cycles at specific intervals, giving the patient a volume preset breath. In between ventilator breaths, the patient may breathe spontaneously. This technique guarantees the patient a set number of mechanical breaths but the overall rate depends on the infant's ability to breathe spontaneously</td>
</tr>
<tr>
<td>Inspiratory/expiratory time (I:E ratio)</td>
<td>The relationship between the duration of inspiration and expiration</td>
</tr>
<tr>
<td>Mean airway pressure (MAP)</td>
<td>The average pressure delivered to the proximal airways from the beginning of one inspiration to the next. Improved oxygenation is the desired effect of increasing the MAP. The MAP can be increased by increasing the PIP, increasing PEEP, and/or increasing the inspiratory flow rate</td>
</tr>
</tbody>
</table>

### Table 6 Conventional Mechanical Ventilation

<table>
<thead>
<tr>
<th>Ventilator Type</th>
<th>Operating Principle</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pressure-cycled</td>
<td>The ventilator is adjusted to deliver a preset pressure during inspiration. Expiration proceeds passively once that pressure is reached. The tidal volume may vary with changes in compliance of the lung and chest wall, and with airway resistance</td>
</tr>
<tr>
<td>Volume-cycled</td>
<td>The ventilator is adjusted to deliver a preset volume during inspiration. Expiration proceeds passively once that volume is reached. The pressure may vary with airway resistance and lung and chest wall compliance, but the volume delivered is constant</td>
</tr>
<tr>
<td>Time-cycled</td>
<td>Administers a predetermined pressure of gas but allows for adjustments in the inspiratory and expiratory times. Currently the most commonly used type of ventilator for infants. It also allows for spontaneous respiratory effort of the infant, making it easier to reduce ventilator support</td>
</tr>
</tbody>
</table>
hemoglobin content and thus to the oxygen saturation. The oxygen saturation is then given by digital readout on the monitoring device. Probes generally last only 1 to 3 days and are a frequent cause of suddenly haywire readings if not replaced often enough. Movement by the infant can also affect the ability of the sensor to pick up the correct reading.

Transcutaneous oxygen monitoring (TcPO₂) is another noninvasive monitoring method. An electrode is placed on a flat surface area of the infant with adequate capillary blood flow, a small amount of fatty deposits, and no bony prominences. With the electrode heated to a higher temperature than the skin, the blood flow increases, lipids in the skin are partially "melted," and oxygen diffusion through tissue beneath the electrode is enhanced. Burns can result if the electrode is not moved at least every 4 hr (Pierce & Turner, 1993), and many institutions prefer pulse oximeters for this reason. Factors such as decreased circulation to the body part (i.e., cold-stressed infant) or increased skin thickness (edema, older infant, pathological skin condition) will affect the TcPO₂ reading (Czervinsek, 1993).

Pulse oximetry and transcutaneous oxygen monitoring may reduce the frequency of invasive blood gas procedures while assessing oxygenation status of the infant with mild respiratory distress or chronic lung disease who requires oxygen for a prolonged period of time. If the infant's acid-base balance requires monitoring, arterial blood gas measurement will be necessary. Transcutaneous carbon dioxide monitoring is also available and can be helpful when monitoring infants with respiratory problems characterized by elevated carbon dioxide partial pressure (PCO₂) (Czervinsek, 1993).

**Hemodynamic Monitoring**

Hemodynamic monitoring of the high-risk neonate is routine but essential. It is accomplished with electrocardiograph (EKG) monitors, peripheral blood pressure monitors, or arterial pressure monitors. EKG monitoring enables the caregiver to observe cardiac function such as rate and rhythm, and to document episodes of brady- or tachycardia (heart rate less than 100 or greater than 200 beats per minute). These alternations in heart rate may be symptoms of the infant's primary diagnosis, such as prematurity, or signs of an undetected problem such as sepsis (D'Harlingue & Durand, 1993). EKGM monitoring requires placement of three leads on the upper chest and abdomen. Extremely premature infants have very thin skin and may require limb bands that do not adhere to the skin and that use sodium chloride rather than electrode gel to activate. Lead placement and function are monitored constantly and sites are altered about every 24 hr. High and low alarm limits are individualized to the institution and the infant, but alarms are always kept on while infants are being monitored.

Peripheral blood pressure monitoring is intermittent and requires an appropriate size cuff placed around an extremity. Most machines used for indirect monitoring can be programmed to give updated readings for specific periods of time, such as every 30 min. Blood pressure cuffs must be the correct size for the infant and are not placed on extremities with intravenous infusions (D'Harlingue & Durand, 1993).

Arterial pressure monitoring is accomplished with an arterial pressure transducer attached to an umbilical or peripheral arterial line and a pressure monitor. This method is used in critically ill infants, infants suffering acute blood loss, and infants receiving cardiac, hypotensive, or hypertensive agents. Because this is a continuous measurement, subtle changes in blood pressure readings are recognized early (Adcock & Consolvo, 1993). The patency of arterial lines is maintained by a constant infusion of fluids at very low rates (usually about 0.5 to 1 mL/hr). These fluids and transducer set-ups are changed about every 24 hr and the transducers calibrated at least every 8 hr to assure accurate readings.

**Nutritional Support**

Nutritional support for the high-risk neonate is aimed at achieving a postnatal growth rate that approximates normal intrauterine growth. For the average infant this corresponds to a weight gain of approximately 15 g per kilogram per day (g/kg/day) (Adcock & Consolvo, 1993). This standard is difficult to apply to the sick or preterm infant because of extraterine factors, such as changed metabolic rate and body composition, as well as differing environmental factors. Calories used to produce energy for temperature regulation, breathing, and other body functions are not available for growth.

Infants with severe respiratory distress, congenital heart defects, or very low birth weight must receive individualized attention to their nutritional needs (Koszarek, 1991). This attention may require a combination of parenteral and enteral nutritional support. Parenteral nutrition, such as intravenous dextrose solution or total parenteral nutrition (TPN), is administered outside the digestive system. Enteral nutrition, such as orogastric gavage feedings or nipple feeding, is given via the digestive system. Selection of the appropriate combination is based on the infant's gestational age, medical condition, and environment.

Total parenteral nutrition has been used as one of the main sources of nutritional support for neonates since the late 1960s. It has been refined and adapted to meet the specific nutritional needs of the infant with low birth weight. The generally accepted criteria for using TPN include any condition that requires delaying enteral...
nutrition. These conditions include infants with very low birth weight and respiratory distress, infants with bowel disease or requiring surgery or both, or infants unable to accept adequate enteral nutrition to meet maintenance calorie requirements. TPN provides the neonate with water, protein, minerals, carbohydrates, vitamins, and fat. Fat emulsion or lipids are administered to prevent essential fatty acid deficiency, to provide a more balanced combination of intravenous calories and a lower concentration of glucose, and to prevent protein intoxication. Computation of the mixture of the components is based on the infant’s gestational and postnatal age, medical condition, and environment.

Infusion pumps provide controlled infusion of parenteral fluids into peripheral veins, arterial lines, or central venous catheters over a prescribed period of time. Infusion pumps vary by manufacturer; some pumps are designed to be used with syringes and others with volumetric chambers. Pumps used with the high-risk neonate must be capable of delivering fluids in tenths of a milliliter because of the need for exact fluid administration and measurement in these tiny patients.

Infants may be started on continuous or intermittent enteral feedings by orogastric or nasogastric feeding tube. The formula or breast milk in continuous drip feedings is infused with the same care as parenteral fluids, with an infusion pump and very low hourly volumes, sometimes starting at 0.1 mL/hr (Townsend, Johnson, & Hays, 1993). Use of an infusion pump allows very slow advances in feeding volumes with similar decreases in the amount of parenteral fluid delivered hourly to maintain the infant at the prescribed fluid intake per kilogram per day. With intermittent bolus feedings, the infant is usually fed every 2 or 3 hr and the volume is gradually increased as the infant gains weight and becomes stronger. Criteria for initiation of nipple feeding vary among institutions.

Commercially prepared stock formulas for the term infant are usually 20 kilocalories per ounce (kcal/oz). Formulas used for preterm infants are higher in the number of calories per ounce, usually 24 kcal/oz, which allows the delivery of more calories to the infant in smaller amounts of fluid. This fluid control can be critical in the preterm infant with bronchopulmonary dysplasia or congestive heart failure. The sick neonate may be fed breast milk from his or her mother by continuous infusion. Because breast milk is about 20 kcal/oz, it is often fortified with commercial preparations that provide additional energy, protein, vitamins, and minerals. Soy protein formulas and elemental formulas are also available for infants with a family history of milk allergies or malabsorption problems (Bryan & Zlotin, 1993).

Case Presentations

The following case presentations are selected to portray specific problems, concerns, and approaches meriting consideration by the neonatal occupational therapist. The Occupational Therapy Practice Guidelines are not meant as sample treatment plans to be used indiscriminately with similar patients. Although many of the principles will apply, the following guidelines are not comprehensive and complete for each case presented. For example, families are a priority in neonatal therapy but are only briefly mentioned below, and duplication of information among case studies is avoided. In addition, current neonatal practice prohibits a uniform recipe-style approach to intervention, as each neonate is an individual with unique problems and responses. The purpose of these case studies is to illustrate application of a medical and technology foundation to occupational therapy practice in the NICU.

Case 1: Timmy

Medical history. Timmy was born at 26 weeks’ gestation, weighing 695 g (see Figure 1). He required intubation and mechanical ventilation for respiratory support due to pulmonary insufficiency. An umbilical arterial catheter (UAC) was placed for blood pressure measurement and blood gas sampling. An umbilical venous catheter (UVC) was placed for infusion of maintenance fluid. Timmy was cared for in a radiant warmer, with his body shielded by cling wrap attached to blanket rolls (without touching his skin) to reduce evaporative heat loss.

Timmy was 8 days old and weighed 675 g when he was routinely referred to occupational therapy. Timmy remained orally intubated on conventional mechanical ventilation with moderate settings (intermittent mandatory ventilation [IMV] or rate of 20, pressures = peak inspiratory pressure [PIP] of 14 and positive end expiratory pressure [PEEP] of 3, fraction of inspired air [FiO2] of 50 or 50%). The UVC had been discontinued, but the UAC was left in place for blood gas monitoring in an effort to wean him from the ventilator and for lab work blood samples. Timmy was receiving TPN and lipids infusion via a percutaneous central line. It was decided to start him on continuous feedings of sterile water at 0.1 cc/hr for trophic effects. A head ultrasound revealed a right Grade I intraventricular hemorrhage (IVH). Timmy was continuously monitored by EKG and by pulse oximetry, as well as by frequent nursing observations, physical assessment, and lab work as indicated.

Occupational therapy practice guidelines. Timmy’s early gestational age and extremely low birth weight suggested significant fragility and vulnerability. Besides increasing his susceptibility to medical complications such as IVH, apnea of prematurity, or infection, Timmy’s extreme immaturity was also affecting his ability to adapt and cope with caregiving procedures and environmental demands. Because Timmy’s postconceptional age was only 27 weeks at time of referral, a reasonable occupational therapy approach could include the following.
Figure 1. Timmy.

Naturalistic observation of Timmy's stress and stability signals, with suggestions for environmental and caregiving modifications to promote stability (Als et al., 1986; VandenBerg, 1990).

Therapeutic positioning. Maintaining the head in midline may reduce risk of IVH, especially in the first week of life (Goldberg, Joshi, Moscoso, & Castillo, 1983). Nesting (i.e., via bunting or blanket rolls) helps promote flexion, which subsequently reduces exposed body surface and thus can lessen heat loss. The extremity containment in nesting also minimizes typical premie positional deformities (e.g., shoulder retraction, hip abduction, and external rotation), and the external neuromuscular control helps promote motoric stability. During phototherapy, however, increased exposed body surface is required for maximal therapeutic effects; some boundaries may be beneficial but must not compromise medical treatment. Sheepskin, or a neonatal water or gel mattress that has been prewarmed, may help maintain skin integrity and allow some positioning changes without direct body manipulation. Small neonatal gel pillows are being studied for potential ability to reduce dolichocephaly, or skull flattening, reduced restlessness in many infants with gel pillows has also been observed. (Note: When using these pillows, avoid excessive neck flexion in supine position that could compromise respiration, and hyperextension of the neck and upper trunk in prone position). The best approach at this stage is to have the staff members who are already involved with the infant (i.e., nurses, respiratory therapists, physicians) adequately trained so that therapeutic positioning is incorporated automatically and consistently, rather than being extra handling by the therapist. If the occupational therapist provides hands-on positioning adjustments, the following guidelines are mandatory:

- **Don't extubate!** Timmy's airway is very small and short; improperly executed position changes can cause the endotracheal tube to become displaced or dislodged.
- **Never** put tension on access lines. Although percutaneous catheters or other central lines are relatively more secure than peripheral intravenous lines (PIV) in the scalp or extremities, adequate slack in all tubing should be automatically checked before any infant is moved.
- **Always** make sure the temperature probe (covered with a reflective foam pad to avoid direct heating of the probe tip by radiant heat, which would falsely elevate the skin temperature reading...
and cause heat output from the warmer to decrease) is exposed to the heat source rather than covered with a blanket roll or body part.

Family intervention and support. Help parents recognize their infant’s communication (stress and stability signals) and learn how to respond appropriately. Consider kangaroo care, a technique of skin-to-skin holding that has been shown to promote infant physiologic stability, quieter sleep, less crying, better alertness, greater weight gain, and earlier hospital discharge with increased parental attachment and confidence (Anderson, 1991; Gale, Franck, & Lund, 1993; Luddington-Hoe & Golant, 1993). Facilitate bedside journal or log with entries by various caregivers; include periodic photographs if possible. Attempt to identify and respond to the needs, strengths, and learning styles of the family.

Case 2: Amy

Medical history. Amy was born at 28 weeks gestation with a weight of 1100 g. She was 34 days old and weighed 1210 g when she was referred to occupational therapy. Amy was initially intubated because of RDS and had required ventilator support since birth. Several attempts to wean her from the ventilator had been unsuccessful due to the development of hypoxia, apnea, and atelectasis each time. Ventilator settings at time of referral were IMV of 40, pressures = PIP of 28 and PEEP of 4, and FiO2 of .60. Her chest X-ray was consistent with bronchopulmonary dysplasia (BPD) for which she was receiving steroid therapy. Amy had been in an incubator, but was transferred back to a radiant warmer after she developed bacterial sepsis; she was completing her course of antibiotics via a PIV.

Like many infants with severe BPD, Amy was a challenge to care for. She was irritable and easily disturbed; the more agitated she became, the more oxygen she needed. Enteral feedings had been stopped when she became septic, but were restarted without problems after several days of antibiotics. Continuous feedings of 24 kcal/oz formula helped to meet Amy’s nutritional needs without fluid overload. Because BPD increases the risk of congestive heart failure and pulmonary edema, her fluid intake was monitored closely to determine whether fluid restriction and diuretics would be necessary to control pulmonary edema.

Occupational therapy practice guidelines. Amy was nearly 5 weeks old, or 53 weeks’ postconceptional age. Her continued need for high ventilator settings (rate of 40, inspiratory pressure of 28, and oxygen concentration of 60%) were indicative of an infant with chronic lung disease who was difficult to ventilate. Maintaining adequate oxygenation and providing good nutritional support were priorities to help Amy grow and develop new lung tissue. The occupational therapy treatment plan must incorporate these priorities.

As Amy’s oxygen saturation dropped with agitation, efforts were made to keep her calm. A quiet environment and clustered care helped decrease stimulation and allowed her to rest. Amy tolerated caregiving procedures better when a second person was available to provide calming opportunities, such as containing her extremities or letting her grasp an adult finger; occupational therapists helped with this when possible.

Because of her frequent agitation and resultant movement, Amy responded better with a bunting than with blanket rolls for nesting and containment. She was able to be swaddled and held if a nurse or the occupational therapist was available. Amy settled in and responded extremely well to these sessions, unless someone tried to talk to her at the same time. The occupational therapist always had assistance by the nurse during transfers before or after a cuddling session to prevent accidental extubation; the warmer was switched to non-servo control while Amy was swaddled to assure a warm bed upon her return. Amy reportedly remained more content for some time after being held.

Prolonged oral intubation had facilitated development of a reverse suck common with ventilator-dependent infants, in which tongue protrusion is exaggerated and stronger than tongue retraction as the tongue passively returns to its starting position. This pattern is different from a true tongue thrust in its mechanics, etiology, and response to intervention. It appears to be iatrogenic, caused by the infant licking at the ventilator tubing, as if trying to push it out of the mouth. Because a reverse suck hinders later feeding efficiency and oral intake by reducing the infant’s ability to strip milk from the nipple and by increasing leakage as the tongue protrudes, it is often helpful to address sucking mechanics while the infant is still intubated. Amy’s occupational therapist used rhythmical downward, inward pressure with an appropriately sized pacifier (shaped like the bottle nipple that would be used later) to inhibit excessive protrusion and facilitate a more normal sucking pattern. Aside from requiring that the endotracheal tube (ETT) be securely taped and lying alongside the pacifier rather than underneath it on the tongue, intubation did not greatly interfere with nor become endangered by these pacifier exercises. As Amy’s sucking pattern improved, the nurses used the pacifier to help Amy with self-calming.

Case 3: Eric

Medical history. Eric (Twin B) was born at 29 weeks gestation weighing 880 g (see Figure 2). His NICU course has been extremely difficult, including multiple infections, a persistent jaundice and an emergency tracheostomy when subglottic stenosis thwarted reintubation efforts after an accidental extubation. At 3 months’ chronological age, or 42 weeks’ postconceptional age, Eric is on...
Eric humidified room air via a trach collar and he has had one trach plug that required resuscitative efforts. Eric has persistent failure to thrive, with a current weight of 1910 g. He has also failed two attempted weans from the incubator by dropping his temperature and developing apnea. Because Twin A has already gone home and his mother is a single parent, family visits are limited. Eric still requires intensive care, but is older and can be managed by occupational therapists more like a chronically ill infant than a fragile premie. He remains awake for up to 2 hr at a time, often becoming agitated when alone but calming with any noninvasive caregiver attention. Although he has failed attempted weans from the incubator, he can be removed from the isolette for occupational therapy sessions after being dressed (in hat, sleeper, or shirt and socks) and swaddled. Occupational therapy continued active involvement with therapeutic positioning (to minimize neck hyperextension, head turning to the right, and arching that is common with young tracheal infants) but also concentrated on oral feedings (which rapidly became one of Eric’s strengths) and standard age-appropriate developmental stimulation. The occupational therapist was initially concerned about bradycardia associated with feedings, but the nurse explained that his lower heart rate (down to the 90s or low 100s beats per minute) was normal for his older age. Eric’s developmental progress has been extremely slow, and caregivers remain concerned about possible central damage from his many hypoxic episodes during these early months.

Occupational therapy practice guidelines. Eric requires intensive care, but is older and can be managed by occupational therapists more like a chronically ill infant than a fragile premie. Eric at one time had a cardiorespiratory monitor that incorporated pulse oximetry within the same piece of equipment. Because movement can interfere with pulse oximetry readings (and Eric was frequently agitated), it is standard to compare pulse rates on the EKG and the pulse oximeter to see if they correlate and thus if the oximeter reading is accurate. As this comparison could not be done when oxygen saturation was included within the EKG, and as Eric’s baseline jaundiced color complicated clinical observations of subtle changes, we asked for (and received) separate pieces of equipment for cardiorespiratory monitoring and pulse oximetry.

Case 4: Bethany

Medical history. Bethany was born near term at 37 weeks’ gestation after a twin pregnancy. Delivery was complicated by cord prolapse of Twin B (Bethany)
It was decided to keep Bethany firmly nested primarily in continuous positive airway pressure (CPAP), and was receiving appropriate fluids by a PIV in her foot. Her nurse wisely sidelying or supine position for the next day or two, passively range her hands and wrists without splinting, try to reduce disruptive stimuli, and monitor her closely. Bethany’s oxygen saturation as measured by pulse oximetry did not significantly differ on the basis of position. She remained irritable and hypersensitive, especially to environmental sounds and position changes, but did calm to sustained proprioceptive input and limb containment. It was decided to keep Bethany firmly nested for the next day or two, passively range her hands and wrists without splinting, try to reduce disruptive stimuli, and monitor her closely.

Bethany quickly weaned to an oxyhood and was on room air by her third day of life; she was also moved to an isolette set on air mode at that time. Occupational therapy provided daily assessments of neuromuscular and neurobehavioral status because changes are typical after severe perinatal asphyxia. Many of these infants are initially hypotonic and unresponsive and later tend to become hypertonic; Bethany did not follow this pattern. By 3 or 4 days of age, Bethany’s muscle tone was no longer increased, no tightness of finger flexors was noted, and she had become relatively lethargic. It was unclear whether these changes represented improvement (i.e., normalizing of muscle tone and improved adaptation without hypersensitivity) or a decline in status. It was encouraging that sucking effort, which initially was absent, could now be elicited, although it was intermittent and disorganized.

Bethany remained lethargic and difficult to arouse for the next week. Sucking frequency and rhythm improved, but Bethany did not gag with oral tube insertion for gavage feedings and physicians were concerned about her feeding potential and safety. The occupational therapist did a trial feeding of 10 cc DsW (5% glucose in water) when Bethany was 12 days old. The intent was to assess feeding mechanics without emphasis on quantity, but Bethany consumed the entire 10 cc in just a few minutes. Suck and swallow were present, but a question was raised about coordination with breathing as sucking bursts tended to be prolonged and followed by a dainty cough. Pacing (removing the nipple from her mouth) was subsequently used to limit sucking bursts to 3 to 4 sucks; a gentle cough still occurred frequently but not consistently. Because neonates have anatomical and physiological features that reduce the risk of aspiration, and Bethany had no symptoms of aspiration on medical physical assessments, a modified barium swallow was considered but not performed. The clinical impression of occupational therapy and medical staff members was that Bethany probably experienced some intermittent laryngeal penetration during feeding and elicited a protective cough that adequately protected her airway.

Although the occupational therapist was eager to advance oral feedings, her physician appropriately proceeded slowly and cautiously, because infants who have sustained severe asphyxia have an increased risk of developing necrotizing enterocolitis. Intravenous fluids were carefully adjusted as oral intake increased. Bethany was also moved to an open crib, which seemed to facilitate an improved sleep-wake cycle and better alertness.

By hospital discharge at 3 weeks of age, Bethany was meeting her nutritional needs by all oral feeds; a cough during feeding was still occasionally heard. Muscle tone was appropriate for her postconceptional age, and both auditory and visual orientation were present. Her local early intervention program stated that Bethany did not qualify for services on the basis of perinatal risk factors alone because of her apparently normal status at discharge, but her NICU occupational therapist will follow her development closely through regular preterm/high-risk clinic visits.

Case 5: Jennifer

Medical history. Jennifer was born at term in an outlying hospital to a 29-year-old mother with no pregnancy or delivery complications (see Figure 3). Birth weight was 2670 g and Apgar scores were 8 and 9 at 1 and 5 min respectively. Jennifer was flown by helicopter to our facility soon after birth due to denuded skin over 75% to 80% of her body involving the anterior trunk and extremities, back, and scalp. A right cleft lip and bilateral cleft palate were noted, as well as fused eyelids, congenital absence of all 4 lacrimal puncta, and dysplastic nails.

Jennifer was considered at high risk for dehydration, electrolyte abnormalities, cold stress, and infection. A UAC and UVC were placed, with fluids begun at 18 cc/hr and soon increased to 25 cc/hr. Jennifer was placed in an incubator to increase her protection from infection and to allow humidified warm air to flow into her environment. Antibiotics were started; Bacitracin was also applied to denuded skin areas to further reduce insensible water loss and reduce risk of infection. The initial impression of dermatology staff members was epidermolysis bullosa...
Jennifer simplex; other possibilities included a less severe hereditary defect or a prenatal infection resulting in staph scalded skin syndrome.

TPN was started on the second day of life; a good nonnutritive suck was noted and a pacifier was used for calming. Denuded areas had begun epithelializing by the third day of life, although the tongue was slightly erythematous. Jennifer's skin was healing well by her sixth day of life. Gavage feeds with breast milk were started on the seventh day, and the first oral feed occurred on the ninth day of life. Fluid requirements of 120 cc/kg/day were increased to 142 cc/kg/day when the warm mist into her isolette was discontinued. Feeds were advanced as tolerated, with TPN gradually decreased as oral intake increased.

A possible immune deficiency was now being considered due to development of a systemic candidal infection, lack of thymus on X-ray, and abnormal lab values consistent with severe combined immune deficiency syndrome. Chromosome analysis revealed a normal 46 XX; low set inferiorly rotated ears were thought to be a spontaneous mutation. Eye adhesions were clipped by ophthalmology personnel on the 18th day of life. Antibiotics were completed on day 32, and Jennifer was discharged home at 5 weeks of age with a guarded prognosis. Diagnoses of Rapp-Hodgkins Ectodermal Dysplasia and moderate immune deficiency were made at a later date.

*Occupational therapy practice guidelines.* Infection control and preserving skin integrity were obvious priorities during occupational therapy intervention with Jennifer. Either a water mattress or gel mattress could protect healing skin and possibly increase comfort. Diligent handwashing and use of sterile gloves were routine. All items introduced into the isolette required previous sterilization. Jennifer was not removed from the isolette for the first several days of life, and then was covered with plastic wrap before being swaddled in blankets to avoid lint in raw skin areas for a few days until the skin was better healed. Family was present daily to provide comfort measures and social contact.

Feeding proved to be more challenging than expected. Jennifer could orally feed with a Haberman feeder (sterilized after each use), but oral feeds initially had to be limited to once per shift due to oral mucosa macerations on the premaxilla from sucking pressure. She was advanced to alternate oral and gavage feeds, but then decreased to every third feed by mouth secondary to palatal breakdown. Formula caloric density was increased to 24 kcal/kg to decrease needed volume and thus decrease total feeding time in hopes of better preserving tissue integrity.
integrity of intraoral structures. Staff members and parents observed that Jennifer appeared more content with the larger volume, however, and use of stock formula was resumed. As Jennifer neared discharge, feeds continued to take 25 to 30 min and 24 kcal/oz formula was again used. Jennifer went home with oral feeds of 75 cc every 4 hr; her mother was extremely competent in her care.

**Case 6: Dylan**

**Medical history.** Dylan was born at term with multiple congenital anomalies consistent with “femoral hypoplasia-unusual facies of an infant of a diabetic mother” syndrome. Dylan was only 4 days old when he was referred to occupational therapy; it was known that he had thoracic hemivertebra with scoliosis, micrognathia, cleft palate, and cardiomegaly. Dylan was on a radiant warmer and remained minimally oxygen dependent with supplemental blow-by oxygen at 3 L/min.

The initial occupational therapy consult was for poor feeding. Dylan was NPO (nothing by mouth) at the first occupational therapy contact, awaiting a barium swallow to evaluate for gastroesophageal reflux and gastric emptying because he had recently begun vomiting when gavage feeds increased over 45 cc. The occupational therapist requested permission to incorporate a modified barium swallow study into the traditional barium swallow because of Dylan's multiple structural anomalies and reported poor feeding. Dylan was transported to the radiology department in his warmer with portable oxygen and a pulse oximeter. The radiology studies showed a coordinated suck-swallow with weak stripping of formula from the nipple, nasal reflux due to cleft palate, extremely poor endurance for oral feeding, some pooling of formula in the esophagus (possibly as the orogastric tube was still in place to allow completion of the traditional barium swallow), no significant gastroesophageal reflux, and intact emptying at the gastric outlet.

**Occupational therapy practice guidelines.** During the first trial feed by the occupational therapist, Dylan was swaddled, removed from the warmer, and held semi-reclined. The temperature probe to the warmer was disconnected and the warmer switched to non-servo control so the bed would be warm upon his return. A Haberman feeder was used and the air hose with blow-by oxygen (now at 5 L) was held along the top of the nipple so the oxygen flow was directed toward his nose. Dylan's first sucking burst of 6 to 7 sucks was uneventful. After the second sucking burst of 3 to 4 sucks, significant nasal regurgitation occurred and Dylan's oxygen saturation dropped to 60 on the pulse oximeter. He was then held more upright to let gravity keep formula away from the nasopharynx, but his oxygen saturation dropped to the low 40s as soon as he began to suck. Even with cessation of feeding and with the oxygen hose held right at his nose, recovery was only partial with a pulse oximeter reading in the 50s and with persistent perioral-perinasal cyanosis. Dylan was then placed back in his warmer and blow-by oxygen flow was increased to 10 L, oxygen saturation rapidly improved to the high 90s.

As Dylan's performance during this feeding trial was similar to what he had previously done with a nurse and with the coordinator of the cleft palate team, the real issue appears to be whether Dylan can be orally fed without seriously compromising oxygenation and ventilation. It was suggested that additional manipulations be tried before this decision was made. Options could include:

- Increasing blow-by oxygen to 10 L before beginning the feed
- Trying a nasal cannula (although nasal regurgitation may be problematic)
- Using a bulb syringe to carefully suction the nose after symptomatic nasal reflux or if breathing becomes more difficult
- Manipulation of position (possibly semi-reclined toward right side-lying, as upright appears to cause Dylan to desaturate)
- Oral feeds with an indwelling orogastric tube. Although Dylan's tongue does not appear posteriorly placed, he is micrognathic and has a cleft palate. If he functions like an infant with Pierre Robin sequence, it is possible his tongue falls back and occludes his airway. An indwelling nasogastric tube has been shown to help maintain an airway in these babies by preventing suction of the tongue along the posterior pharyngeal wall and possibly providing a sensory stimulus to help move the tongue forward. Dylan has an orogastric tube, as a nasogastric tube might reduce oxygen flow through the partially occluded nares. Although this is speculative clinical reasoning, it might be worth a try before eliminating oral feed attempts.
- If these manipulations are not successful, consider trying a few cc as therapeutic exercise to maintain an intact suck-swallow mechanism while providing nutrition by tube supplements. The cause of Dylan's desaturation and continued oxygen dependence needs continued medical exploration. The pulse oximeter was extremely helpful in providing an objective measure of oxygenation compromise and will be used to measure future performance and, hopefully, progress.

**Conclusion**

The neonatal intensive care unit is considered an advanced area of practice for specially trained occupational therapists. This article provided an introduction to neonatal thermoregulation, respiratory care, hemodynamic monitoring, and nutritional support; application of this
information to neonatal occupational therapy practice was illustrated in case study presentations. The neonatal occupational therapist must strive to develop a strong medical foundation, including familiarity with relevant technology and terminology, an awareness of pathophysiology of individual diseases, and an understanding of the rationale for basic medical management. This foundation is essential to the provision of safe, effective occupational therapy evaluation and intervention strategies in the neonatal intensive care unit.

References


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