120 or above 160 beats per minute, respiratory rate below 40 or above 60, and transcutaneous Po_2 below 55 mm Hg or above 80 mm Hg. Suggestions for caregiving modifications that may reduce stress for the infant are developed from the summary. The physical therapist can share this information with the NICU team and provide suggestions for modifying the environment and caregiving activities. These suggestions may pertain to lighting, noise level, activity level, bedding, aids to self-regulation, interaction, timing of manipulations, and facilitation of transitions from one activity to another. A list of training centers may be obtained from the National NIDCAP Center, 320 Longwood Ave., Boston, MA 02115.

TEST OF INFANT MOTOR PERFORMANCE

The TIMP is the first test designed specifically for use by physical and occupational therapists (see Chapter 1) to assess the functional motor performance of infants from 32 weeks' postconceptional age to 4 months post term (Campbell et al., 2001). The construct of the TIMP is postural alignment and selective control necessary for functional movements in early infancy. Items from the TIMP were adapted from neurologic and developmental tests by Brazelton (1984), Dubowitz and Dubowitz (1981b), and Amiel-Tison and Grenier (1986). The scoring scales and additional items were developed by Campbell and colleagues (1995). The TIMP requires approximately 25 to 45 minutes for administration and scoring (Campbell & Hedeker, 2001). Spontaneous and elicited movements are assessed with separate subscales. The Observed Scale consists of dichotomously scored behaviors that reflect the infant's spontaneous attempts to orient the body, to selectively move individual body segments, and to perform qualitative movements such as ballistic or oscillating movements (Campbell et al., 1995). Examples of observed behaviors include individual finger and ankle movements, reaching, and aligning the head in midline while supine. The Elicited Scale items are scored on a five-, six-, or seven-point hierarchic scale (Campbell, 1999a). Elicited behaviors reflect the infant's response to positioning and handling in a variety of spatial orientations and to visual and auditory stimuli. Examples include rolling prone with head righting when the leg is rotated across the body and turning the head to follow a visual stimulus or to search for a sound in prone.

The TIMP is a valid and reliable assessment for infants up to 4 months post term (Campbell, 1999a; Campbell et al., 1995; Campbell & Kolobe, 2000). Test-retest reliability is good across the age range of the TIMP ($r = 0.89$) (Campbell, 1999a). Construct validity of the TIMP has been established, specifically the ability of the TIMP to discriminate on the basis of both medical complications and maturation (Campbell et al., 1995; Campbell & Hedeker, 2001). Scores on the TIMP increase with increasing postconceptional age. Infants with medical complications have lower scores than healthy infants of the same age (Campbell et al., 1995). In addition, the TIMP can discriminate among infants at risk for motor delays (Campbell & Hedeker, 2001). A study has also been performed that looks at the relationship between environmental demands placed on infants during caregiving activities, including play, and the demands placed on the infant during the administration of the Elicited Scale items of the TIMP (Murney & Campbell, 1998). During caregiving activities, approximately 50% of the demands placed on the infants corresponded to items on the TIMP. In addition, 98% of the TIMP Elicited Scale items corresponded to observed environmental demands (Murney & Campbell, 1998). These findings suggest that TIMP items are representative of typical environmental demands, lending further support to the construct validity of the TIMP. In addition to construct validity, concurrent validity of the TIMP has also been examined (Campbell & Kolobe, 2000). The TIMP and Alberta Infant Motor Scales (AIMS) have similarities in their items. When scoring the same infants at 3 months of age, the TIMP and AIMS identify a similar group of infants with low motor performance. These findings support the concept of concurrent validity (Campbell & Kolobe, 2000).

The TIMP has also been examined for predictive validity (Campbell et al., 2002; Flegel & Kolobe, 2002). TIMP scores within the first 3 months predict AIMS scores at 6, 9, and 12 months. The greatest predictive validity is between the 3-month TIMP scores and the 12-month scores on the AIMS (Campbell et al., 2002). The TIMP can be used for early identification of very young infants at risk for poor motor performance (Barbosa et al., 2003; Campbell et al., 2002; Flegel & Kolobe, 2002). The TIMP scores identified delayed functional motor performance in children later diagnosed with cerebral palsy as early as 3 months of age (Barbosa et al., 2003).

The TIMP is currently being normed. Normative data is currently being collected on the TIMP. Although normative data are not available, data are available for typical performance on the TIMP for the different age ranges. Until norms are available, these scores can be used to identify infants who may benefit from early intervention (Campbell, 1999b). The TIMP is a useful tool with preterm and high-risk infants. Time may be a factor with infants who are not able to tolerate more than 15 to 20 minutes of handling. Making sure the infant is in the optimal state and administering each item only once can reduce the amount of time needed to perform the TIMP.

MORGAN NEONATAL NEUROBEHAVIORAL EXAMINATION

The Morgan Neonatal Neurobehavioral Examination (NNE) was designed to quantify the neurobehavioral abilities of infants between 37 and 40 weeks of conceptional age (Morgan et al., 1988). The authors stated that a quantitative rather than a qualitative assessment would be valuable in identification of infants at risk for developmental disabilities and would also provide a research tool for evaluating early intervention protocols. The test was constructed from items taken from the work of Brazelton (1984) and Dubowitz and Dubowitz (1981a). The 27 assessment items are organized into sections on tone and motor patterns, primitive reflexes, and behavioral responses. Interestingly, the response decrement items of the Brazelton scale were not included because the authors believed that high-risk infants must habituate themselves to noxious sounds and lights because they are continuously exposed to them in an NICU. A three-point scoring system is used for each item, with the highest total score being 81 and the lowest possible score being 27.

The NNE was standardized on 54 healthy full-term infants at 2 days of age and on 298 high-risk infants at 37 to 40 weeks of conceptional age (gestational age at birth plus chronologic age) or at discharge, whichever came first. Scores fell into three clusters for the high-risk infants, which correlated with conceptional age and not with severity of illness or gestational age at birth. These clusters represented performance at greater than 36 weeks, 32 to 36 weeks, and less than 32 weeks of gestational age. This suggests that the NNE reflects gestational maturation and quantitatively represents neurobehavioral status. Intertester reliability is reported as 88% agreement by item and 95% agreement by total score (Morgan et al., 1988). Lee and colleagues (1989) reported that the NNE can be used to predict motor outcome for high-risk infants born at or below 1500 g or between 37 and 42 weeks of gestation.

Although not widely used, the Morgan NNE provides the therapist useful information about the infant's motor response, reflexes, and behavior. The assessment does not require much time, an advantage for infants who do not tolerate handling well. Although the NNE can be used to predict motor outcome for high-risk infants born at or below 1500 g or between 37 and 42 weeks' gestation, scoring is based on the development of healthy full-term infants, not infants born at high risk or prematurely.

ORAL-MOTOR EXAMINATION

Oral-motor examination is another competency of the neonatal therapist. Two useful measures are the Neonatal Oral-Motor Assessment Scale (NOMAS) (Braun & Palmer, 1985/1986), which has been updated (Gaebler & Hanzlik, 1996), and the Nursing Child Assessment Feeding Scale (NCAFS) (Barnard & Eyres, 1979). The NOMAS measures components of nutritive and nonnutritive sucking. Variables assessed during sucking include rate, rhythmicity, jaw excursion, tongue configuration, and tongue movement. A pilot study determined cutoff scores for oral-motor disorganization and dysfunction. The NCAFS assesses parent-infant feeding interaction and evaluates responsiveness of parents to their infant's cues, signs of distress, and social interaction during feeding.

There are also instruments to study the pressure generated by each suck and the length of sucking bursts such as the Kron Nutritive Sucking Apparatus (Medoff-Cooper & Gennaro, 1996) and the Actifier (Finan & Barlow, 1996), which can also be used as a method for stimulation of intraoral tissue in neonates.

HIGH-RISK PROFILES

Examination and evaluation may lead to identification of the infant as having one of three basic high-risk profiles described by Sweeney and Swanson (2001). Although not all neonates fit the behaviors described in the high-risk profiles, the profiles address the need for individualized levels of stimulation and approaches to the management of infants with abnormal tone and movement (Sweeney & Swanson, 2001). The profiles represent the extremes in sensorimotor and interactional behavior. The profiles identify impairments in muscle tone, behavioral characteristics, and interactional styles associated with motor status, and therefore, have implications for the development of individualized goals, outcomes, and intervention strategies.

The infant who is irritable and hypertonic is often in a state of overstimulation, with poor self-quieting abilities. These infants have a low tolerance for handling and position changes. Extensor patterns of posture and movement predominate, with limited antigravity flexion. Movement is disorganized and tremulous, with poor midline orientation. Feeding is difficult as a result of increased tone in the oral musculature. Visual tracking is also difficult.

The infant who is hypotonic and lethargic is often difficult to arouse even at feeding time. Crying is weak and of short duration. Hypotonicity is noted in the trunk, intercostal, and neck accessory musculature, with decreased respiratory capacity. An infant who fits this profile demonstrates paucity of movement, weak and uncoordinated sucking, and poor interactive capability.

Infants who are hypotonic and lethargic mold themselves to the arm's of the person holding them and use contact with the surface for stabilization.

The infant who is disorganized demonstrates fluctuating tone and movement and is easily overstimulated. An infant who fits this profile remains passive when left alone but responds well to swaddling. When calm, the infant interacts and feeds well; but when distracted and overstimulated, the infant becomes hypertonic and irritable.

DEVELOPMENTAL INTERVENTIONS

Neonatal physical therapy is a subspecialty of pediatric physical therapy that emerged in the mid-1970s (Sweeney & Chandler, 1990). As specialists in the NICU, it is important to know the evidence guiding and supporting our practice. Several studies have shown support for developmental intervention in the NICU. Scarr-Salapatek and Williams (1973) reported greater developmental progress at 4 weeks and 12 months in infants who received developmental intervention that included visual, tactile, and kinesthetic stimulation in the nursery. Leib and associates (1980) reported that an intervention program consisting of visual, tactile, kinesthetic, and auditory stimulation enhanced the quality of development for high-risk preterm infants. In addition, Field and co-workers (1986) demonstrated that preterm infants benefited from a program of tactile and kinesthetic stimulation in the NICU. Parker and colleagues (1992) reported the positive benefits of a developmental intervention program in the NICU for infants of mothers of low socioeconomic status. Als and co-workers (1994) have also demonstrated the positive effects of individualized developmentally supportive care. Although physical therapists were not involved in these studies, the interventions are those typically performed during physical therapy intervention in the NICU.

Although there is evidence to support developmental interventions for preterm infants in the NICU, stimulation in the form of tactile, kinesthetic, visual, and auditory stimulation has the potential to be harmful. Physical therapists, therefore, must carefully monitor infants during intervention. Monitoring includes oxygen saturation, heart rate, respiratory rate, and identification of behavioral signs indicating stress. Careful monitoring of infants during intervention is essential to avoid potentially adverse physiologic effects.

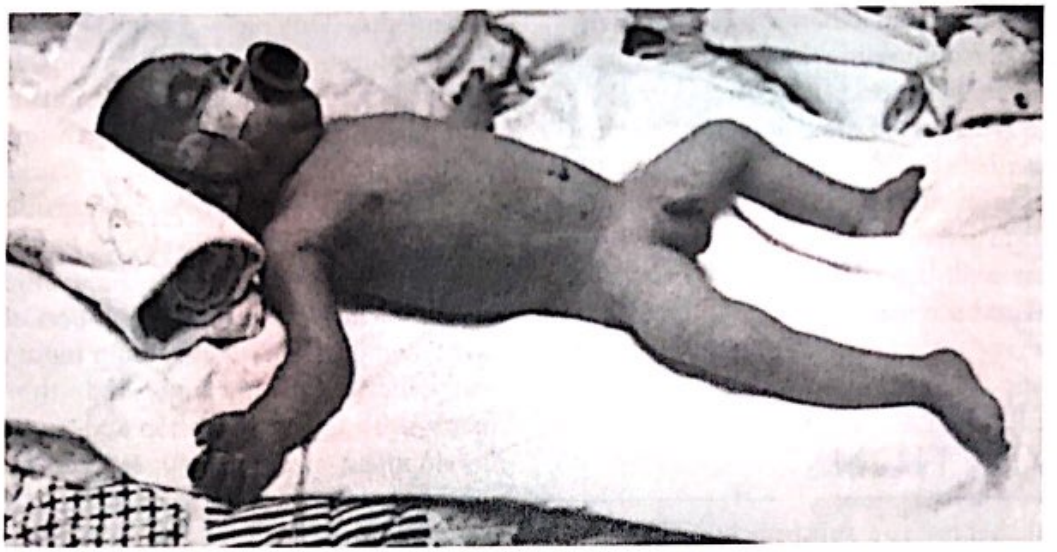
The goals of physical therapy for neonates may include reduction or prevention of impairments in muscle tone, ROM, postural adaptation, and control of extremity movements. Outcomes include improved regulation and organization of motor behavior, interactions with caregivers and the environment, and family interaction (Campbell, 1985; Sweeney & Swanson, 1990). Parents, primary nurses, and other caregivers should be involved in the development of goals and outcomes and coordination of the care plan. Strategies for both direct intervention and consultation include modification of the environment, positioning, promotion of efficient movement, and modulation of sensory input (e.g., oral-motor stimulation, hydrotherapy, and the use of water mattresses). Parent education and support regarding the development and input appropriate for neonates is an important aspect of intervention (Gottwald & Thurman, 1990).

The design for a care plan should be individualized based on infant and caregiver needs. Factors to consider include the infant's postconceptional age, physiologic abilities, and behavioral abilities. These individualized care plans should include the provision of social interaction stimuli during alert periods, avoidance of handling during quiet sleep periods, and immediate termination or alteration of stimulation producing avoidance responses (Campbell, 1985). Avoidance responses include vomiting, sneezing, coughing, hiccoughing, gagging, sighing, respiratory changes, and changes in tone (Als, 1986). While the neonate is in the NICU, the environment should be modified to avoid overstimulation by excessive light, noise, or physical handling (Avery & Glass, 1989; Field, 1990). Caregivers should provide tactile and kinesthetic stimuli that are contingent on the neonate's responses to alleviate stress, if possible, or to help the infant prepare for, or adapt to, stress-producing stimuli.

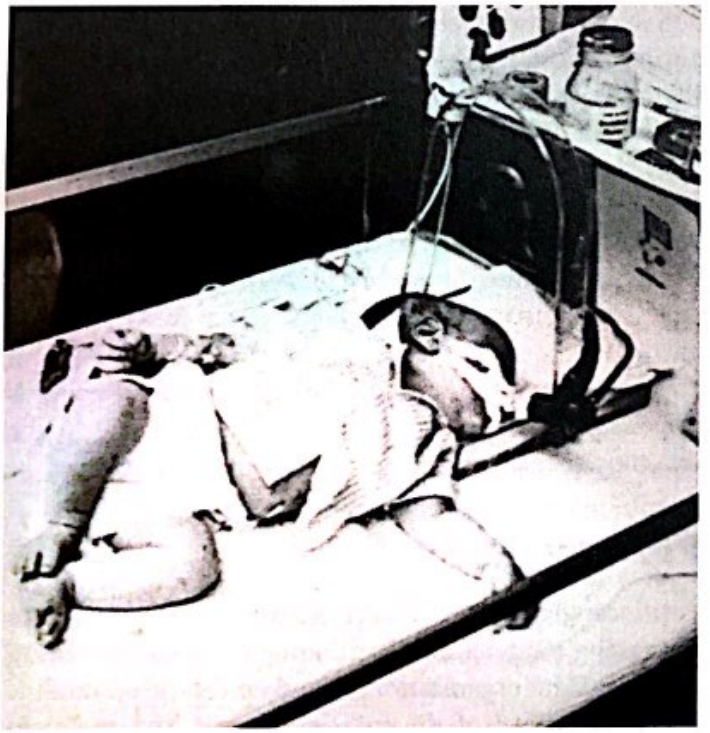
POSITIONING

Positioning has already been mentioned in relation to improving oxygenation. Positioning is also important to promote state organization, stimulate the flexed midline positions typical of the full-term infant, and maintain ROM (Sweeney & Swanson, 2001). The premature infant does not have the opportunity to develop physiologic flexion and may demonstrate hypotonia (Fig. 35-10). The preterm infant must also contend with ventilatory and infusion equipment, which often exaggerates extension of the neck, trunk, and extremities. Hypotonic extended limbs may also be fixed to padded boards to protect intravenous lines (Fetters, 1986). Prolonged hyperextension may lead to neck extensor muscle contracture (Sweeney & Swanson, 2001) (Fig. 35-11).

The prone position, with the head in midline and elevation of the head at 30°, has the beneficial effects of



• **Figure 35-10** Characteristic hypotonic posture with minimal movement against gravity in a premature infant at 4 months of age. *(From Sweeney, JK, & Swanson, MW. At-risk neonates and infants: NICU management and follow-ups. In Umphred, DA [Ed.]. Neurological Rehabilitation, 2nd ed. St. Louis: Mosby, 1990, p. 218.)*



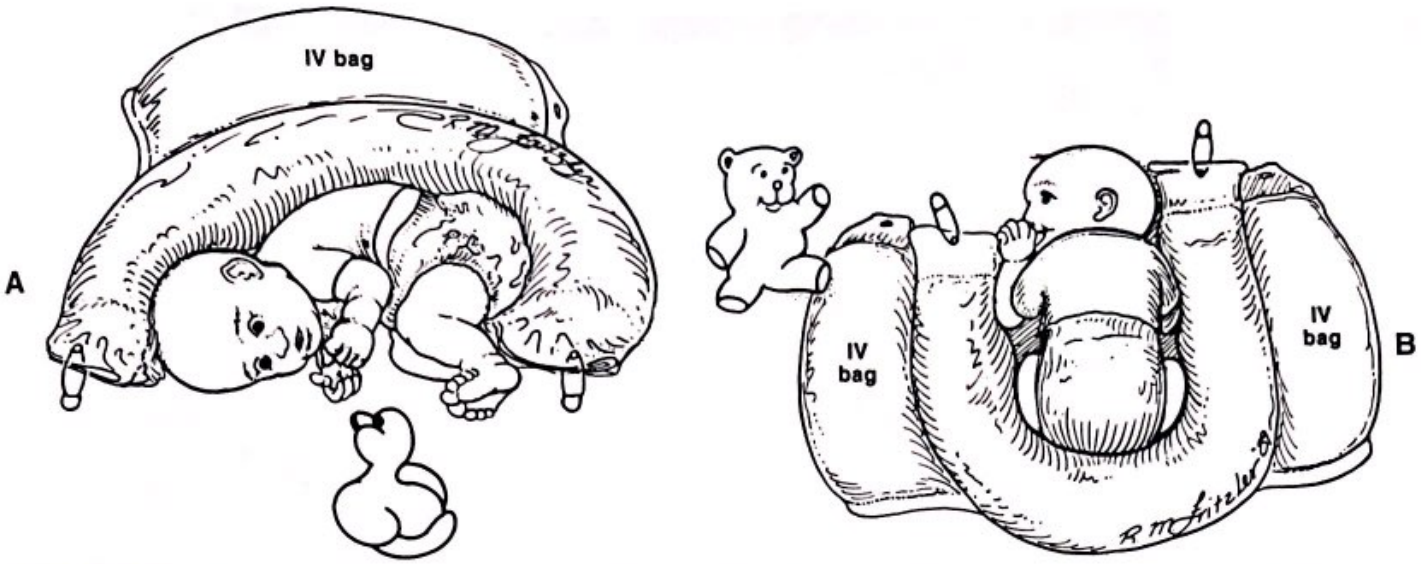
• **Figure 35-11** Neck hyperextension posture exaggerated by position of the endotracheal tube. *(From Sweeney, JK, & Swanson, MW. At-risk neonates and infants: NICU management and follow-ups. In Umphred, DA [Ed.]. Neurological Rehabilitation, 2nd ed. St. Louis: Mosby, 1990, p. 201.)*

decreasing intracranial pressure, gastroesophageal reflux, and aspiration and increasing stomach emptying (Semmler, 1989; Wolfson et al., 1992). Many different methods are used for placing the infant in prone and side-lying positions, including blanket or diaper rolls, sandbags, customized foam inserts, buntings, and nests (Creger & Browne, 1995; Semmler, 1989; Sweeney & Swanson, 2001) (Figs. 35-12 through 35-14). The desired posture includes neck flexion or chin tucking, trunk flexion, shoulder protraction, posterior pelvic tilt, and symmetric flexion of legs. When supine positioning is used, the head is positioned in midline and blanket rolls may be placed along the infant's sides and under the shoulder girdle for support, as well as under the knees. Supported semierect positions while the infant is swaddled may also be beneficial to elicit the alert state, head righting, and visual and auditory tracking.

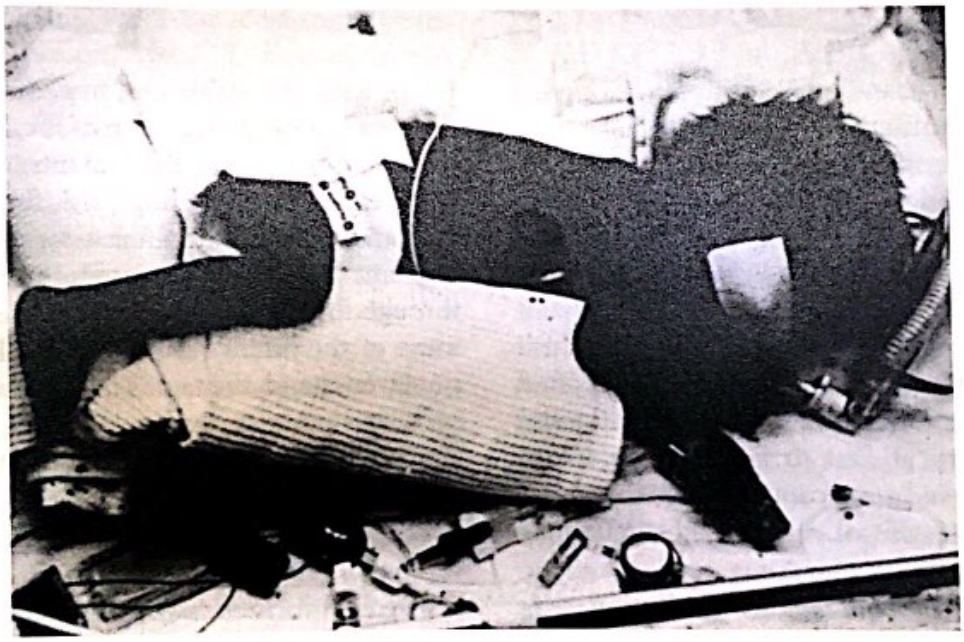
Hammocks and water mattresses are also used in conjunction with positioning. Supine positioning in a hammock has been shown to be associated with a higher neuromuscular maturity score on the Assessment of Maturity Scale (Ballard, 1979) and a more relaxed state as shown by lower heart rate and respiratory rate (Keller et al., 2003). Water mattresses are soft, and the surface intermittently oscillates, providing gentle vestibular and proprioceptive stimulation. Water mattresses have proved effective in decreasing apnea, reducing position-induced head flattening, and improving skin conditions (Deiriggi, 1990; Piecuch, 1988; Sweeney & Swanson, 2001; Taylor & Dalbec, 1989). Positions should be changed throughout the day, especially for infants with respiratory problems involving increased secretions (Crane, 1987).

SENSORIMOTOR STIMULATION

Physical therapy intervention includes appropriate interaction with the neonate, which involves sensory



• **Figure 35-12** Positioning in flexion using a long blanket roll reinforced by a sand or intravenous bag. *(From Sweeney, JK, & Swanson, MW. At-risk neonates and infants: NICU management and follow-ups. In Umphred, DA [Ed.]. Neurological Rehabilitation, 2nd ed. St. Louis: Mosby, 1990, p. 201.)*



• **Figure 35-13** Side-lying positioning to reduce extension posturing. *(From Sweeney, JK, & Swanson, MW. At-risk neonates and infants: NICU management and follow-ups. In Umphred, DA [Ed.]. Neurological Rehabilitation, 2nd ed. St. Louis: Mosby, 1990, p. 200.)*

input. Psychologists and nurses have studied the effect of supplemental stimulation on weight gain, visual responsiveness, growth, development, and sensorimotor functions (Fetters, 1986; Field, 1980; Heriza, 1989; Mueller, 1996). Most of these studies have involved the relatively healthy premature infant weighing more than 1000 g at birth. Little research has been published on the effects of supplemental stimulation of the sicker, VLBW, or asphyxiated newborn (Campbell, 1985). The majority of supplemental stimulation studies used predetermined, packaged, nonindividualized treatments (Harris et al., 1988). In a few studies, sensory stimulation interventions have been individualized and based on behavioral cues from the infant (Heriza, 1989; Als, 1986; Fetters, 1986). Mueller (1996) has published an integrated review of research on multimodal stimulation of premature infants. Interestingly, she included developmental care as one type of multimodal stimulation. In this context, sensorimotor stimulation would include any sensory input, such as the visual input of the therapist's face,

• **Figure 35-14** Use of anterior roll and pacifier promotes flexed position. *(From Sweeney, JK, & Swanson, MW. At-risk neonates and infants: NICU management and follow-ups. In Umphred, DA [Ed.]. Neurological Rehabilitation, 2nd ed. St. Louis: Mosby, 1990, p. 200.)*

tactile input, physical handling, positioning, offering visual or auditory stimuli, and social interaction.

The purposes of providing contingent sensorimotor stimulation to infants in the NICU include improving behavioral organization, promoting integration of the sensory systems, enhancing development of motor and interactive abilities, and supporting parent-infant attachment. Sensory input must be provided in a graded manner that is contingent on the infant's behavioral cues. Gradual introduction of unimodal sensory stimulation may be necessary at first to allow the infant to maintain physiologic and state control. Once the infant is able to maintain state control, multimodal stimuli may be used.

Techniques to aid the infant's state organization, self-consolation, and orienting include encasement (gentle tactile contact with infant's head or soles of feet in a gently flexed position), swaddling, and firm tactile input to the soles of the feet. Constant vigilance must be practiced to weigh the costs and benefits of any intervention. The therapist must be constantly aware of changes in heart rate, blood pressure, and oxygen levels, as well as state control or organization changes during and after intervention.

Using the high-risk infant assessment profiles of Sweeney and Swanson (2001) as a point of reference, it is obvious that strategies of intervention should be individualized. The infant who is lethargic and hypotonic needs stimulation to reach the alert state and facilitation of proximal neck and trunk musculature, whereas the infant who is irritable and hypertonic needs calming to the alert state and inhibition of increased tone.

Als (1986) found that infants who were dependent on a respirator and at high risk for BPD improved self-regulation capabilities after a series of procedures were implemented. These procedures included inhibition through firm tactile input to the soles of the feet, encasement of the infant's trunk and back of the head in the caregiver's hand, the tactile input of a finger to squeeze or suck, and nonnutritive sucking of a finger or a "suckel" (something for the infant to suck on). By contrast, sensory inputs such as rocking, stroking, and talking were not well tolerated by infants.

Methods of calming an infant who is irritable and hypertonic include swaddling, that is, wrapping the infant in a blanket or using a bunting. If swaddling is done with flexed, midline extremity positioning, there may be facilitation of flexor tone, increased hand-to-mouth awareness, and decreased jittery and disorganized movements. Vestibular stimulation in a horizontal position with the infant swaddled has a calming effect.

Procedures used to promote an alert state include positioning in supported sitting, swaddling, and using a bunting or tactile containment. In the infant who is more robust, carefully graded, arrhythmic vestibular input, such as quick rocking in the upright position, and light touch may be used for state arousal. Once the alert state is reached and maintained, sensory input such as visual or auditory stimuli may be added one at a time and modified as indicated by the infant's response.

Visual stimuli include the therapist's face, a black-and-white bull's-eye target, and a red ball. Auditory stimuli include classical instrumental music, calling the infant's name, and a soft rattle (Burke et al., 1995; Collins & Kuck, 1991). Once the infant can maintain an alert state and can fixate on an object, visual tracking may be attempted.

Early movement experiences such as hand-to-mouth contact, shoulder protraction and retraction, pelvic tilt, movement of extremities against gravity, and holding of the head in midline may also be facilitated (Campbell, 1985). Hand-to-hand, hand-to-knee, and hand-to-foot activities are encouraged to provide tactile stimulation and flexion input.

ORAL-MOTOR THERAPY

The infant in the special care nursery often exhibits feeding difficulties related to neurologic immaturity, abnormal muscle tone, depressed oral reflexes, or prolonged use of endotracheal tubes for mechanical ventilation (Sweeney & Swanson, 2001). Decreased tongue mobility, tongue thrusting, poor seal on nipple due to weak lip closure, weak sucking, or hypersensitivity of the oral area may also have a negative impact on feeding (Semmler, 1989).

Nonnutritive sucking should be encouraged early with the immediate aim of self-consolation and the long-term goal of normal oral-motor development (Gaebler & Hanzlik, 1996; Pickler et al., 1996). Achieving a quiet alert state and positioning the infant in supported sitting with semiflexion of the neck may also enhance feeding behavior. Methods of tactile stimulation of facial muscles and intraoral structure and external support to the infants' cheeks have been described and have resulted in weight gain and decreased hospital stay for infants in level II special care (Anderson, 1986; Gaebler & Hanzlik, 1996; Harris, 1986; Sweeney & Swanson, 2001). Waber and colleagues (1998) reported that once infants were able to breastfeed or bottle feed, they fed on demand rather than on a schedule, showed more feeding cues, and had a shorter hospital stay.

FAMILY-CENTERED CARE

Family-centered care is a concept of service delivery to infants and their families (Rosenbaum et al., 1998). Using a family-centered approach to care recognizes the family as a constant in the infant's life and recognizes the individual strengths and needs of each family. The concept of family-centered care involves the parents in the decision-making process and promotes collaboration between the physical therapist and parents (Dunst et al., 1991; Harrison, 1993; Johnson, 1990; Rosenbaum et al., 1998; Shelton & Stepaneck, 1995). In the NICU, the health care team includes the parents as active members. Each family has unique strengths and needs that the physical therapist must recognize and integrate into the interventions in order to provide the family as well as the infant with the necessary services. Using a family-centered approach to intervention, physical therapists should provide parents with information both specific to their infant and general information about development. Parents who are provided information using a family-centered approach display improvements in their caregiving abilities compared to parents who only receive general information on development (Unanue, 2002).

DEVELOPMENTAL FOLLOW-UP AFTER DISCHARGE FROM THE SPECIAL CARE NURSERY

Infants who are discharged home from the NICU or special care nursery often need early intervention services. As part of the Individuals with Disabilities Education Improvement Act of 2004 (Public Law 108-446), infants and toddlers under the age of 3 are provided services under Part C. Part C provides developmental services to meet the needs of the infant; however, developmental follow-up of infants after discharge varies from state to state and with the particular problems or risk factors of each infant. Primary care is usually provided by a pediatrician in private practice, through a hospital, or through a community-based clinic. An interdisciplinary program such as an early intervention program also provides assessment, monitoring, and direct intervention, as well as a support group for parents (Hack, 1992; Leonard, 1988). As part of early intervention services under Part C, each infant must have a comprehensive individualized family service plan (IFSP) which is developed by the team. In keeping with family-centered care, the parent is an active member of the team developing the IFSP. Because many early intervention programs have waiting lists for physical therapy and occupational therapy, services initially may be provided by the community visiting nurse association or other home care agencies.

Physical therapists working with families and infants in the NICU have a role in the transition of infants and families to early intervention services. The physical therapist needs to communicate with the therapist or agency

providing services to that infant and family. Although the ideal situation would be for the early intervention team to meet with the family and therapists providing services in the NICU, this is not realistic for providers who live a distance from the NICU. In this case, the physical therapist must provide the community therapist with as much information as possible regarding current interventions. In some areas, physical therapists working in home care agencies are not pediatric therapists and require information and guidance from the hospital-based staff.

Level III nurseries typically have a developmental follow-up clinic for high-risk infants. Clinics vary in staffing and their criteria for follow-up care. Factors such as birth weight, gestational age, Apgar scores, time on a ventilator, IVH, seizures, and environmental factors such as maternal drug or alcohol use are useful criteria. Results of developmental assessments administered at the follow-up clinic are useful in determining whether specialized therapy services are necessary beyond the provision of general recommendations for development and parent education. Specialized referral for nutrition, audiology, and ophthalmology also is made when necessary.

The physical therapist has a role in the follow-up care of infants as a member of an early intervention program, a visiting nurse association, or a follow-up clinic. As a team member, the therapist plays an important role in the examination and monitoring of sensorimotor development and pulmonary function in order to prevent or decrease the risk of impairment or functional limitation and provide parent education and anticipatory guidance (Platzker et al., 1988; Resnick et al., 1987; Rothberg, 1991; Thom, 1988). Interventions such as positioning, sensory stimulation, and facilitation of movement are also provided when necessary. The physical therapist also assists families in coordination of care and initiates referrals to other professionals and community agencies when appropriate.

The following two hypothetical case histories serve as examples of the neonates seen in the special care nursery and illustrate their physical therapy examination, evaluation, and intervention. Several other excellent case histories have been published (Campbell, 1999b; Sweeney & Swanson, 2001).

SUMMARY

The special care nursery is a specialized setting for providing high technologic medical interventions to newborn infants who are unable to sustain basic physiologic processes secondary to premature birth or other neonatal complications. Provision of services to infants and families in the special care nursery is a subspecialty area of pediatric physical therapist practice. Knowledge of fetal and infant development, medical complications, and competency in monitoring vital signs and behaviors are essential for providing therapy services in the special care nursery. The examination and evaluation process includes issues identified by families and members of the team and observation of how the infant is positioned and responds to caregiving procedures. Standardized tests and measures are useful in evaluation of infant development and identification of areas of need. Depending on an infant's needs and ability to tolerate sensory stimulation and movement, interventions may include positioning, strategies to minimize physiologic stress, and sensorimotor development. Prevention of musculoskeletal impairments is an important outcome of intervention. Communication and coordination of care with team members, families, and external agencies such as early intervention providers are important components of intervention. Perhaps, the most important role of the physical therapist is education and instruction of family members in the infant's behavioral cues and responses and handling and caring for the infant in anticipation of transition to home.

After discharge, an important role of the physical therapist in high-risk follow-up clinics is to monitor infant motor development, address family information needs and concerns, and coordinate care with community service providers.

CASE STUDIES

TOMMY

Tommy was born at 24 weeks' gestational age and had a birth weight of 525 g (1.16 lb). His mother is 25 years old. Her pregnancy was complicated by severe preeclampsia and excessive weight gain during the last month of pregnancy. Tommy was blue and limp at birth with Apgar scores of 2 at 1 minute and 4 at 5 minutes. He received bag/mask ventilation and was intubated in the delivery room. Tommy was mechanically ventilated for 9 weeks. He required multiple attempts to wean him from the ventilator. Tommy remained on supplemental oxygen via nasal cannula after his extubation. Tommy's hospital course was complicated by severe BPD, a grade II IVH revealed by head ultrasound on day of life 7, a patent ductus arteriosus treated with indomethacin, and hyperbilirubinemia.

Tommy was referred to physical therapy at 6 weeks of life (30 weeks' postconceptional age). Practice Pattern 5C: Impaired Motor Function and Sensory Integrity Associated with Nonprogressive Disorders of the Central Nervous System — Congenital Origin or Acquired in Infancy or Childhood (American Physical Therapy Association, 2001) was used to guide the physical therapy examination, evaluation, and intervention. The physical therapist reviewed Tommy's history through a chart review and spoke with his primary nurse. His nurse reported that Tommy was irritable and felt very stiff when moving his extremities. The physical therapist observed Tommy during routine nursing care using the Neonatal Individualized Developmental Care and Assessment Program (Als, 1984). He demonstrated a low tolerance to handling and position changes and was frequently overstimulated. Tommy's stress signs included irregular respirations, increased heart rate, startling, grunting, and straightening extremities with tension. He displayed few approach and calming behaviors. Tommy was difficult to calm, but would eventually calm with a pacifier and swaddling. During the observation, Tommy was not able to transition to or maintain an awake alert state. With handling, he frequently was asleep or in a cry state, but did not transition to an alert state even for a brief period of time.

During the physical therapy examination, the physical therapist noted poor midline orientation, limited antigravity movement, and increased tone in his extremities. Tommy displayed postures and movements that were predominantly into extension, tremulous, and disorganized. His upper extremities were frequently in a position of scapular retraction with shoulder abduction and external rotation with elbow flexion. He displayed a head preference to the right with tightness noted in left neck rotation. Tommy demonstrated impaired visual tracking. When presented with a visual stimulus, Tommy displayed an increase in stress signs. He was not able to maintain an alert state. With any type of handling, Tommy quickly transitioned to a cry state. He required frequent breaks and consoling by the therapist during the examination. Calming Tommy was difficult, but he would eventually calm with containment and his pacifier.

As part of the test and measures in the ongoing physical therapy examination, the physical therapist performed the Test of Infant Motor Performance (TIMP) when Tommy reached 34 weeks' postconceptional age (PCA) and had been extubated for 1 week. The TIMP was chosen because (1) the test is appropriate for use from 32 weeks' PCA until 4 months post term; (2) it is a valid and reliable test; (3) the TIMP discriminates infants with various risks for delays; and (4) the TIMP can identify very young infants at risk for poor motor performance. Tommy scored a 40. Based on the suggested ranges for performance on the TIMP, Tommy scored below average for an infant at 34 weeks' PCA (Campbell, 1999b). Tommy's performance on the TIMP showed poor visual tracking, poor response to an auditory stimuli, poor head control, trunk hyperextension, and asymmetries between the right and left side when rolling was facilitated from both the arms and legs. Tommy only transitioned to brief alert states during the testing and required frequent rest breaks to calm.

Tommy's mother does not visit the NICU very often. She lives 3 hours away and relies on others for transportation to the hospital. She is not able to stay close to the hospital because she has two other children and Tommy's father is not involved. She went back to work shortly after Tommy's birth in order to be off when he is discharged home. She is afraid of losing her job if she takes time off because the health insurance for Tommy and his siblings is through her employer. His mother tries to come on weekends when other family members are able to watch her other children and she can get a ride to the hospital. She feels very torn between being at the hospital and working and being home for her other children. She is very interested in learning about Tommy and how she can best care for him. Because Tommy's mother was not present during the physical therapy examination, the physical therapist called his mother to discuss the purpose of physical therapy intervention and to determine what her goals and needs were. The physical therapist also arranged to meet with Tommy's mother on the weekend when she is at the hospital. The physical therapist leaves weekly notes at bedside for Tommy's mother, including activities she can do while visiting.

Using a family-centered approach, the physical therapist developed a plan of care for Tommy that included handling tolerance, positioning, state transitions, gentle neck ROM, and parent education. When developing the plan, the physical therapist took into account Tommy's mother's goals and needs that were discussed over the phone. Physical therapy was provided three to five times a week to Tommy's tolerance for the duration of his hospital stay. Goals for Tommy included the following: (1) maintenance of an alert state during physical therapy intervention with increasing duration throughout his stay; (2) visual fixing and tracking to both the left and right; (3) auditory tracking; (4) increasing antigravity movements into flexion; (5) ability to self-calm; (6) increasing head control in prone, supine, and supported sitting; (7) midline orientation; (8) decreasing tightness in his neck; and (7) mother's independence in reading Tommy's behavioral cues and understanding appropriate developmental activities.

Physical therapy intervention included positioning to increase flexion in Tommy's extremities and to provide midline orientation. This was achieved through swaddling or using rolls under Tommy's legs and alongside his arms and head. Interventions to increase handling tolerance and state transitions included swaddling, containment, and gentle rocking or patting. Once Tommy was able to maintain an alert state for brief periods, unimodal stimulation such as an adult's face or voice was initiated to engage visual and auditory tracking. The therapist also performed gentle ROM to Tommy's neck to decrease the tightness on his left side as a result of his right-sided head preference. Self-calming was also a focus of intervention. This was achieved through facilitated hands to midline and hands to mouth. As Tommy tolerance for handling and position changes improved, the therapist also began to work on developmental activities such as increasing head control in prone, supine, and supported sitting. The physical therapist constantly monitored Tommy's physiologic and state responses to her interaction with him.

The physical therapist communicated on a daily basis with Tommy's nurse. She also posted signs at Tommy's bedside for his mother, as well as for the nurses in the evenings. On a weekly basis, the physical therapist updated his progress and added to the activities Tommy's mother could do while she was visiting. The physical therapist met with his mother on several Saturdays when she was able to get a ride to the hospital for the weekend. Tommy's mother was concerned with her abilities to identify when Tommy was overstimulated, how to calm him, and how to position him in bed correctly. The therapist was able to teach Tommy's mother how to identify Tommy's behavioral cues, help Tommy to calm himself, and properly position Tommy to provide flexion and midline orientation. The therapist also instructed mom in developmental activities that she could do with Tommy while she visited. The physical therapist recommended several books for Tommy's mother to read, including the book by Klein and Ganon (1998). The information provided to Tommy's mother was modified at each meeting to accommodate for her needs and goals as she became more comfortable with reading behavioral cues, calming, and positioning.

Tommy was ready for discharge from the hospital at 40 weeks' PCA. At this time, Tommy was reassessed using the TIMP. His TIMP score was 61. Based on the suggested ranges for performance on the TIMP, Tommy again scored below average for an infant at 40 weeks' PCA, although overall he had shown improvements in his score (Campbell, 1999b). At discharge, Tommy had achieved many of his goals. He was visually tracking left and right approximately 30°. He would turn his head right and left in response to auditory stimuli. Tommy moved his extremities in small ranges against gravity. His movements continued to be jerky. Tommy was able to bring his hands to midline and to mouth. He no longer had a head preference to the right and did not have tightness in his neck ROM. He was easily consoled with rocking, gentle patting, hands to mouth, and sucking on a pacifier. Tommy was able to consistently clear his face in prone and was beginning to make attempts at head control while in supported sitting. Tommy's mother was able to read his behavioral signs and respond appropriately to them. She felt comfortable taking him home. As part of the discharge plan, the physical therapist referred Tommy to a local home health agency and an early intervention program close to his house. The physical therapist contacted the social worker within the NICU to arrange for the physical therapy services that Tommy would need at home. Tommy was also to return to the NICU follow-up clinic, which included physical, occupational, and speech therapy.

SUSAN

Susan was born at full term and her birth weight was 3300 g (7.26 lb). Her mother is 32 years old; her pregnancy was uncomplicated. Susan was born with the cord wrapped around her neck and was blue and limp. Her Apgar scores were 2 at 1 minute and 6 at 5 minutes. She received bag/mask ventilation, but did not require intubation in the delivery room. Shortly after her transfer to the NICU, Susan began having seizures with associated decreases in respiratory rate requiring bagging. On neurologic examination, Susan had absent suck and gag reflexes and was slow to respond to stimuli.

Susan was referred for a physical therapy examination on day 2 of life. The physical therapist used Practice Pattern 5C: Impaired Motor Function and Sensory Integrity Associated with Nonprogressive Disorders of the Central Nervous System — Congenital Origin or Acquired in Infancy or Childhood (American Physical Therapy Association, 2001) to guide her examination, evaluation, and intervention. The physical therapist reviewed Susan's medical history during the chart review and spoke to nursing about any concerns noted during routine caregiving activities. The physical therapist observed Susan before, during, and after a routine nursing activity using the Neonatal Individualized Developmental Care and Assessment Program (NIDCAP) (Als, 1984). Susan demonstrated poor handling tolerance with an increase in stress signs. Stress signs included a decrease in respiratory rate, startles, arching, and cry. Susan also demonstrated an inability to maintain an awake state and poor state transitions. She quickly transitioned from

being lethargic to a hyperalert state to cry without any intervening quiet alert states. In addition, Susan was not able to calm herself by using self-regulatory behaviors such as hand to mouth, hands to midline, and sucking.

A family-focused approach to physical therapy was used in the NICU. This approach incorporates the family's goals and needs into the care plan. As part of this, the physical therapist spoke with Susan's parents, explaining the role of the physical therapist in Susan's care. Both parents appeared very interested in Susan, although they did voice concerns about her poor handling tolerance and sudden changes from being asleep to crying. Both parents were interested in activities they could do with Susan and appropriate methods to calm her down.

As part of the examination process, the physical therapist performed the Morgan Neonatal Neurobehavioral Examination (NNE) (Morgan et al., 1988). The NNE was chosen because (1) it has been standardized on full-term and high-risk infants; (2) it is quick and easy to administer; and (3) the items include muscle tone and motor patterns, reflexes, and behavioral responses. Susan demonstrated low tone, poor head and trunk control, weak suck, and delayed or absent reflexes. Susan received a total score of 60 on the test. This indicates that she was performing below that of typical full-term infants.

In addition to administering the NNE, the therapist observed Susan's postures, movements, state control, and interactive behaviors. Susan's strengths included brief response to voice and calming with tight swaddling and rocking. Susan did not have any limitations in ROM in her arms or legs. When Susan did move her arms and legs, she was able to move them in very global patterns through her available range. When supine, Susan postured with her lower extremities in a frog-leg position and her upper extremities abducted and externally rotated. Susan was either lethargic with eyes closed or crying during the examination and was very difficult to console. The therapist also noted that Susan was unable to bring her hands to midline or to mouth. She displayed minimal movements of the arms and legs. Movements were jerky and into extension. Susan did not focus on or track objects left or right.

The physical therapist developed a plan of care for Susan that included positioning, handling tolerance, and sensory stimulation. Physical therapy was provided three to five times a week to Susan's tolerance or up to 30 minutes. This episode of care was for the duration of Susan's stay in the hospital. As part of the care plan, positioning was done to encourage midline and symmetry, to bring her shoulders forward (prevent abduction and external rotation), and to promote hip flexion with neutral rotation. Pictures of side-lying, supine, and prone positions were posted at bedside for both nursing and the family.

Handling tolerance was increased using swaddling with gentle sensory stimulation such as rocking. As handling tolerance increased, Susan transitioned to a cry state less often. With this decrease in crying, the therapist worked on state transitions to an awake, alert state. Along with the development of handling tolerance, the therapist worked on self-calming behaviors such as hands to midline and hands to mouth. Slowly, visual stimulation was brought into the plan to work on fixing and following.

The physical therapist wrote specific outcomes to guide her physical therapy intervention with Susan. These goals focused on the limitations that were noted during Susan's evaluation. The goals included the following: (1) transitions to a quiet alert state and maintenance of this state for increasing periods of time; (2) ability to briefly self-calm using hands to mouth, holding onto clothes, or sucking on hand or pacifier; (3) visual fixing on an object for a brief time with increasing duration over time; (4) developmental activities such as lifting head to clear face in prone or briefly (1 to 2 seconds) holding head vertical in midline in supported sitting; and (5) parents independent in caring for her physical needs at home. Although the therapist wrote five outcomes for Susan, they were not all addressed within each session.

Weekly updates were posted at the bedside for both parents with activities to improve response to handling, improve self-calming, and encourage an alert state. Susan's mother visited daily. The physical therapist included Susan's mother in all treatment sessions in which she was present. This was at least once or twice per week. The physical therapist explained all activities during Susan's treatment session. In addition, the therapist actively involved Susan's mother in handling and self-calming activities. All activities discussed and demonstrated during a treatment session with Susan's mother were written down and pictures included for the mother's reference. The therapist also communicated with nursing daily. The physical therapist requested a referral for occupational therapy to work on oral-motor skills. The therapist reexamined Susan weekly to update her plan of care. The therapist was involved in her discharge planning, which included a referral to an early intervention program, as well as the hospital's NICU follow-up clinic.

After discharge from the NICU, Susan showed improvements, achieving several of her outcomes. Her parents were independent in her caregiving and felt very comfortable with the activities the therapist gave them. Susan was tolerating handling for longer periods of time, approximately 15 to 20 minutes. She was able to

transition to a quiet alert state for a brief period of time, up to 5 minutes. She still was easily overstimulated, which caused her to transition to a cry state and decreased her handling tolerance. She began fixing on stationary objects, such as a black-and-white picture. She did not follow objects left or right. In addition, Susan inconsistently cleared her face while prone, continued to have a complete head lag with pull-to-sit, and did not make attempts to maintain her head vertically in midline while in supported sitting. Susan began receiving home physical therapy through a local early intervention program with frequent visits to the follow-up clinic for monitoring of her progress.

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