Chapter 2: The Newborn Infant

Adam A. Rosenberg, MD; Theresa Grover, MD

INTRODUCTION

The newborn period is defined as the first 28 days of life. In practice, however, sick or very immature infants may require neonatal care for many months. There are three levels of newborn care. Level 1 refers to basic care of well newborns of 35 weeks' gestation or more, neonatal resuscitation, and stabilization prior to transport. Level 2 refers to specialty neonatal care of premature infants greater than 1500 g or more than 32 weeks' gestation. Level 3 is subspecialty care of higher complexity ranging from 3A to 3D based on newborn size and gestational age, availability of medical subspecialties, advanced imaging, pediatric ophthalmology, pediatric general surgery, cardiac surgery, and extracorporeal membrane oxygenation. Level 3 care is often part of a perinatal center offering critical care and transport to the high-risk mother and fetus as well as the newborn infant. A level 4 center has additional capabilities to care for complex surgical conditions including cardiac surgery with bypass.

THE NEONATAL HISTORY

The newborn medical history has three key components:

1. Maternal and paternal medical and genetic history
2. Maternal past obstetric history
3. Current antepartum and intrapartum obstetric history

The mother's medical history includes chronic medical conditions, medications taken during pregnancy, unusual dietary habits, smoking history, occupational exposure to chemicals or infections of potential risk to the fetus, and any social history that might increase the risk for parenting problems and child abuse. Family illnesses and a history of congenital anomalies with genetic implications should be sought. The past obstetric history includes maternal age, gravidity, parity, blood type, and pregnancy outcomes. The current obstetric history includes the results of procedures during the current pregnancy such as ultrasound, amniocentesis, screening tests (rubella antibody, hepatitis B surface antigen, serum quadruple screen in the second trimester or first trimester ultrasound screening for nuchal translucency coupled with measurement in maternal serum of human chorionic gonadotropin and pregnancy-associated plasma protein A to screen for genetic disorders, HIV [human immunodeficiency virus]), and antepartum tests of fetal well-being (eg, biophysical profiles, nonstress tests, or Doppler assessment of fetal blood flow patterns). Pregnancy-related maternal complications such as urinary tract infection, pregnancy-induced hypertension, eclampsia, gestational diabetes, vaginal bleeding, and preterm labor should be documented. Significant peripartum events include duration of ruptured membranes, maternal fever, fetal distress, meconium-stained amniotic fluid, type of delivery (vaginal or cesarean section), anesthesia and analgesia used, reason for operative or forceps delivery, infant status at birth, resuscitative measures, and Apgar scores.

ASSESSMENT OF GROWTH & GESTATIONAL AGE

It is important to know the infant's gestational age because normal behavior and possible medical problems can be predicted on this basis. The date of the last menstrual period is the best indicator of gestational age, if known, and if menses were regular. Fetal ultrasound provides supporting information. Postnatal physical characteristics and neurologic development are also clues to gestational age. Table 2–1 lists the physical and neurologic criteria of maturity used to estimate gestational age by the Ballard method. Adding the scores assigned to each neonatal physical and neuromuscular sign yields a score corresponding to gestational age.
Table 2–1. New Ballard score for assessment of fetal maturation of newly born infants.\(^a\)

<table>
<thead>
<tr>
<th>Neuromuscular Maturity</th>
<th>Score</th>
<th>Record Score Here</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Neuromuscular Maturity Sign</strong></td>
<td>-1</td>
<td>0</td>
</tr>
<tr>
<td>Posture</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Square window (wrist)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Arm recoil</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Popliteal angle</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scarf sign</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heel to ear</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Physical Maturity</th>
<th>Score</th>
<th>Record Score Here</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Physical Maturity Sign</strong></td>
<td>-1</td>
<td>0</td>
</tr>
<tr>
<td>Skin</td>
<td>Sticky, friable, transparent</td>
<td>Gelatinous, red, translucent</td>
</tr>
<tr>
<td>Lanugo</td>
<td>None</td>
<td>Sparse</td>
</tr>
<tr>
<td>Plantar surface</td>
<td>Heel toe 40–50 mm; -1 &lt; 40 mm -2</td>
<td>&gt; 50 mm; no crease</td>
</tr>
<tr>
<td>Breast</td>
<td>Imperceptible</td>
<td>Barely perceptible</td>
</tr>
<tr>
<td>Eye/Ear</td>
<td>Lids fused loosely: -1</td>
<td>Lids open; pinna flat; stays folded</td>
</tr>
<tr>
<td>Genitals (male)</td>
<td>Scrotum flat, smooth</td>
<td>Scrotum empty; faint rugae</td>
</tr>
<tr>
<td>Genitals (female)</td>
<td>Clitoris prominent &amp; labia flat</td>
<td>Prominent clitoris &amp; small labia minora</td>
</tr>
</tbody>
</table>

\(^a\)See text for a description of the clinical gestational age examination.


Disappearance of the anterior vascular capsule of the lens is also helpful in determining gestational age. Until 27–28 weeks' gestation, the lens capsule is covered by vessels; by 34 weeks, this vascular plexus is completely atrophied. Foot length,
from the heel to the tip of the longest toe, also correlates with gestational age in appropriately grown infants. The foot measures 4.5 cm at 25 weeks' gestation and increases 0.25 cm/wk until term.

If the physical examination indicates a gestational age within 2 weeks of that predicted by the obstetric dates, the gestational age is as assigned by the obstetric dating. Birth weight and gestational age are plotted on standard grids (Figure 2–1) to determine whether the birth weight is appropriate for gestational age (AGA), small for gestational age (SGA, also known as intrauterine growth restriction or IUGR), or large for gestational age (LGA). Birth weight for gestational age in normal neonates varies with race, maternal nutrition, access to obstetric care, and environmental factors such as altitude, smoking, and drug and alcohol use. Whenever possible, standards for newborn weight and gestational age based on local or regional data should be used. Birth weight related to gestational age is a screening tool that should be supplemented by clinical data when entertaining a diagnosis of IUGR or excessive fetal growth. These data include the infant's physical examination and other factors such as parental size and the birth weight—gestational age of siblings.

Figure 2–1.

An important distinction, particularly in SGA infants, is whether a growth disorder is symmetrical (weight, length, and occipitofrontal circumference [OFC] all ≤ 10%) or asymmetrical (only weight ≤ 10%). Asymmetrical growth restriction implies a problem late in pregnancy, such as pregnancy-induced hypertension or placental insufficiency. Symmetrical growth restriction implies an event of early pregnancy: chromosomal abnormality, drug or alcohol use, or congenital viral infections (Table 2–2). In general, the outlook for normal growth and development is better in asymmetrically growth-restricted infants whose intrauterine brain growth has been spared.

Table 2–2. Causes of variations in neonatal size in relation to gestational age.

**Infants large for gestational age**
- Infant of a diabetic mother

**Infants small for gestational age**

- **Asymmetrical**
  - Placental insufficiency secondary to pregnancy-induced hypertension or other maternal vascular disease
  - Maternal age > 35 y
  - Poor weight gain during pregnancy
  - Multiple gestation

- **Symmetrical**
  - Maternal drug abuse
    - Narcotics
    - Cocaine
    - Alcohol
  - Chromosomal abnormalities
  - Intrauterine viral infection (eg, cytomegalovirus)

The fact that SGA infants have fewer problems (such as respiratory distress syndrome) than AGA infants of the same birth weight but a lower gestational age has led to the misconception that SGA infants have accelerated maturation. SGA infants, when compared with AGA infants of the same gestational age, actually have increased morbidity and mortality rates.

Knowledge of birth weight in relation to gestational age allows anticipation of some neonatal problems. LGA infants are at risk for birth trauma; LGA infants of diabetic mothers are also at risk for hypoglycemia, polycythemia, congenital anomalies, cardiomyopathy, hyperbilirubinemia, and hypocalcemia. SGA infants are at risk for fetal distress during labor and delivery, polycythemia, hypoglycemia, and hypocalcemia.

American Academy of Pediatrics Committee on Fetus and Newborn: Levels of neonatal care. Pediatrics 2012;130:587
[PubMed: 22926177].
[PubMed: 21353087].
[PubMed: 21353090].
Rosenberg A: The IUGR newborn. Semin Perinatol 2008;32:219
[PubMed: 18482625].

**EXAMINATION AT BIRTH**
The extent of the newborn physical examination depends on the condition of the infant and the setting. Examination in the
delivery room consists largely of observation plus auscultation of the chest and inspection for congenital anomalies and
birth trauma. Major congenital anomalies occur in 1.5% of live births and account for 20%–25% of perinatal and neonatal
deaths. Because infants are physically stressed during parturition, the delivery room examination should not be extensive.
The Apgar score (Table 2–3) should be recorded at 1 and 5 minutes of age. In severely depressed infants, scores can be
recorded out to 20 minutes. Although the 1- and 5-minute Apgar scores have almost no predictive value for long-term
outcome, serial scores provide a useful description of the severity of perinatal depression and the response to resuscitative
efforts.

Table 2–3. Infant evaluation at birth—Apgar score.¹

<table>
<thead>
<tr>
<th>Score</th>
<th>0</th>
<th>1</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heart rate</td>
<td>Absent</td>
<td>Slow (&lt; 100)</td>
<td>&gt; 100</td>
</tr>
<tr>
<td>Respiratory effort</td>
<td>Absent</td>
<td>Slow, irregular</td>
<td>Good, crying</td>
</tr>
<tr>
<td>Muscle tone</td>
<td>Limp</td>
<td>Some flexion</td>
<td>Active motion</td>
</tr>
<tr>
<td>Response to catheter in nostril³</td>
<td>No response</td>
<td>Grimace</td>
<td>Cough or sneeze</td>
</tr>
<tr>
<td>Color</td>
<td>Blue or pale Body pink; extremities blue</td>
<td>Completely pink</td>
<td></td>
</tr>
</tbody>
</table>

¹One minute and 5 minutes after complete birth of the infant (disregarding the cord and the placenta), the following
objective signs should be observed and recorded.

³Tested after the oropharynx is clear.


Skin color is an indicator of cardiac output because of the normal high blood flow to the skin. Stress that triggers a
catecholamine response redirects cardiac output away from the skin to preserve oxygen delivery to more critical organs.
Cyanosis and pallor are thus two useful signs suggestive of inadequate cardiac output.

Skeletal examination at delivery serves to detect obvious congenital anomalies and to identify birth trauma, particularly in
LGA infants or those born after a protracted second stage of labor where a fractured clavicle or humerus might be found.

The number of umbilical cord vessels should be determined. Normally, there are two arteries and one vein. In 1% of
deliveries (5%–6% of twin deliveries), the cord has only one artery and one vein. This minor anomaly slightly increases the
risk of associated defects. The placenta should be examined at delivery. Small placentas are always associated with small
infants. The placental examination includes identification of membranes and vessels (particularly in multiple gestations) as
well as placental infarcts or clots (placental abruption) on the maternal side.

EXAMINATION IN THE NURSERY

The purpose of the newborn examination is to identify abnormalities or anomalies that might impact the infant's well-being,
and to evaluate for any acute illness or difficulty in the transition from intrauterine to extrauterine life. The examiner should
have warm hands and a gentle approach. Start with observation, then auscultation of the chest, and then palpation of the
abdomen. Examination of the eyes, ears, throat, and hips should be performed last, as these maneuvers are most disturbing
to the infant. The heart rate should range from 120 to 160 beats/min and the respiratory rate from 30 to 60 breaths/min.
Systolic blood pressure on day 1 ranges from 50 to 70 mm Hg and increases steadily during the first week of life. Blood
pressure is influenced more significantly by perinatal asphyxia and mechanical ventilation than it is by gestational age. An
irregularly irregular heart rate, usually caused by premature atrial contractions, is common, benign, and usually resolves in
the first days of life.

Approximately 15%–20% of healthy newborns have one minor anomaly (a common variant that would not impact the
infant's well-being; eg, a unilateral transverse palmar [simian] crease, or a single umbilical artery). Those with a minor
anomaly have a 3% risk of an associated major anomaly. Approximately 0.8% of newborns have two minor anomalies, and
0.5% have three or more, with a risk of 10% and 20%, respectively, of also having a major malformation. Other common
minor anomalies requiring no special investigation in healthy infants include preauricular pits, a shallow sacral dimple
without other cutaneous abnormality within 2.5 cm of the anus, and three or fewer café au lait spots in a white infant or five
or fewer in an African-American infant.
**Skin**

Observe for bruising, petechiae (common over the presenting part), meconium staining, and jaundice. Visible jaundice in the first 24 hours is never normal, and generally indicates either a hemolytic process, or a congenital hepatitis, either of which requires further evaluation. Peripheral cyanosis is commonly present when the extremities are cool or the infant is polycythemic. Generalized cyanosis merits immediate evaluation. Pallor may be caused by acute or chronic blood loss or by acidosis. In dark-skinned infants, pallor and cyanosis should be assessed in the lips, mouth, and nail beds. Plethora suggests polycythemia. Note the presence of vernix caseosa (a whitish, greasy material covering the body that decreases as term approaches) and lanugo (the fine hair covering the preterm infant's skin). Dry skin with cracking and peeling of the superficial layers is common in postterm infants. Edema may be generalized (hydrops) or localized (eg, on the dorsum of the feet in Turner syndrome). Check for birthmarks such as capillary hemangiomas (lower occiput, eyelids, and forehead) and mongolian spots (bluish-black pigmentation over the back and buttocks). There are many benign skin eruptions such as milia, miliaria, erythema toxicum, and pustular melanosis that are present in the newborn period, but more serious conditions may be indicated by blistering or erosive lesions. See Chapter 15 for a more in-depth description of these conditions.

**Head**

Check for cephalohematoma (a swelling over one or both parietal bones that is contained within suture lines) and caput succedaneum (edema of the scalp over the presenting part that crosses suture lines). Subgaleal hemorrhages (beneath the scalp) are uncommon but can cause extensive blood loss into this large potential space, resulting in hypovolemic shock. Skull fractures may be linear or depressed and may be associated with cephalohematoma. Check for the presence and size of the fontanelles. The anterior fontanelle varies from 1 to 4 cm in any direction; the posterior fontanelle should be less than 1 cm. A third fontanelle is a bony defect along the sagittal suture in the parietal bones and may be seen in syndromes, such as trisomy 21. Sutures should be freely mobile, but are often overriding just after birth. Craniosynostosis, a prematurely fused suture causing an abnormal cranial shape, is more easily diagnosed a few days or more after birth.

**Face**

Unusual faces may be associated with a specific syndrome. Bruising from birth trauma (especially with face presentation) and forceps application should be identified. Face presentation may cause soft tissue swelling around the nose and mouth and significant facial distortion. Facial nerve palsy is most obvious during crying; the unaffected side of the mouth moves normally, giving an asymmetric grimace.

**Eyes**

Subconjunctival hemorrhages are a frequent result of birth trauma. Less commonly, a corneal tear (presenting as a clouded cornea), or a hyphema (a layering of blood in the anterior chamber of the eye) may occur. Ophthalmologic consultation is indicated in such cases. Extraocular movements should be assessed. Occasional uncoordinated eye movements are common, but persistent irregular movements are abnormal. The iris should be inspected for abnormalities such as speckling (Brushfield spots seen in trisomy 21) and colobomas. Retinal red reflexes should be present and symmetrical. Dark spots, unilateral blunted red reflex, absent reflex, or a white reflex all require ophthalmologic evaluation. Leukocoria can be caused by glaucoma (cloudy cornea), cataract, or tumor (retinoblastoma). Infants with suspected or known congenital viral infection should have a retinoscopic examination with pupils dilated to look for chorioretinitis.

**Nose**

Examine the nose for size and shape. In-utero compression can cause deformities. Because infants younger than 1 month of age are obligate nose breathers, any nasal obstruction (eg, bilateral choanal atresia or stenosis) can cause respiratory distress. Unilateral choanal atresia can be diagnosed by occluding each naris, although patency is best checked by holding a cold metal surface (eg, a chilled scissor) under the nose, and observing the fog from both nares on the metal. Purulent nasal discharge at birth suggests congenital syphilis (“snuffles”).

**Ears**

Malformed or malpositioned (low-set or posteriorly rotated) ears are often associated with other congenital anomalies. The tympanic membranes should be visualized. Preauricular pits and tags are common minor variants, and may be familial. Any external ear abnormality may be associated with hearing loss.
Mouth

Epithelial (Epstein) pearls are benign retention cysts along the gum margins and at the junction of the hard and soft palates. Natal teeth may be present and sometimes must be removed to prevent their aspiration. Check the integrity and shape of the palate for clefts and other abnormalities. A small mandible and tongue with cleft palate is seen with Pierre-Robin syndrome and can present as respiratory difficulty, as the tongue occludes the airway; prone positioning can be beneficial. A prominent tongue can be seen in trisomy 21 and Beckwith-Wiedemann syndrome. Excessive oral secretions suggest esophageal atresia or a swallowing disorder.

Neck

Redundant neck skin or webbing, with a low posterior hairline, is seen in Turner syndrome. Cervical sinus tracts may be seen as remnants of branchial clefts. Check for masses: mid-line (thyroglossal duct cysts), anterior to the sternocleidomastoid (branchial cleft cysts), within the sternocleidomastoid (hematoma and torticollis), and posterior to the sternocleidomastoid (cystic hygroma).

Chest & Lungs

Check for fractured clavicles (crepitus, bruising, and tenderness). Increased anteroposterior diameter (barrel chest) can be seen with aspiration syndromes. Check air entry bilaterally and the position of the mediastinum by locating the point of maximum cardiac impulse and assessment of heart tones. Decreased breath sounds with respiratory distress and a shift in the heart tones suggest pneumothorax (tension) or a space-occupying lesion (eg, diaphragmatic hernia). Pneumomediastinum causes muffled heart sounds. Expiratory grunting and decreased air entry are observed in hyaline membrane disease. Rales are not of clinical significance at this age.

Heart

Cardiac murmurs are common in the first hours and are most often benign; conversely, severe congenital heart disease in the newborn infant may be present with no murmur at all. The two most common presentations of heart disease in the newborn infant are (1) cyanosis and (2) congestive heart failure with abnormalities of pulses and perfusion. In hypoplastic left heart and critical aortic stenosis, pulses are diminished at all sites. In aortic coarctation and interrupted aortic arch, pulses are diminished in the lower extremities.

Abdomen

Check for tenderness, distention, and bowel sounds. If polyhydramnios was present or excessive oral secretions are noted, pass a soft catheter into the stomach to rule out esophageal atresia. Most abdominal masses in the newborn infant are associated with kidney disorders (eg, multicystic or dysplastic, and hydronephrosis). When the abdomen is relaxed, normal kidneys may be felt but are not prominent. A markedly scaphoid abdomen plus respiratory distress suggests diaphragmatic hernia. Absence of abdominal musculature (prune belly syndrome) may occur in association with renal abnormalities. The liver and spleen are superficial in the neonate and can be felt with light palpation. A distended bladder may be seen as well as palpated above the pubic symphysis.

Genitalia & Anus

Male and female genitals show characteristics according to gestational age (see Table 2–1). In the female infant during the first few days, a whitish vaginal discharge with or without blood is normal. Check the patency and location of the anus.

Skeleton

Check for obvious anomalies such as absence of a bone, club-foot, fusion or webbing of digits, and extra digits. Examine for hip dislocation by attempting to dislocate the femur posteriorly and then abducting the legs to relocate the femur noting a clunk as the femoral head relocates. Look for extremity fractures and for palsies (especially brachial plexus injuries) and evidence of spinal deformities (eg, scoliosis, cysts, sinuses, myelomeningocele). Arthrogryposis (multiple joint contractures) results from chronic limitation of movement in utero that may result from lack of amniotic fluid or from congenital neuromuscular disease.
Neurologic Examination

Normal newborns have reflexes that facilitate survival (eg, rooting and sucking reflexes), and sensory abilities (eg, hearing and smelling) that allow them to recognize their mother soon after birth. Although the retina is well developed at birth, visual acuity is poor (20/400) because of a relatively immobile lens. Acuity improves rapidly over the first 6 months, with fixation and tracking becoming well developed by 2 months.

Observe the newborn's resting tone. Normal term newborns should exhibit flexion of the upper and lower extremities and symmetrical spontaneous movements. Extension of the extremities should result in spontaneous recoil to the flexed position. Assess the character of the cry; a high-pitched cry with or without hypotonia may indicate disease of the central nervous system (CNS) such as hemorrhage or infection, a congenital neuromuscular disorder, or systemic disease. Check the following newborn reflexes:

1. **Sucking reflex**: The newborn sucks in response to a nipple in the mouth; observed by 14 weeks' gestation.

2. **Rooting reflex**: Head turns to the side of a facial stimulus, present by 28 weeks' gestation.

3. **Traction response**: The infant is pulled by the arms to a sitting position. Initially, the head lags, then with active flexion, comes to the midline briefly before falling forward.

4. **Palmar grasp**: Evident with the placement of the examiner's finger in the newborn's palm; develops by 28 weeks' gestation and disappears by age 4 months.

5. **Deep tendon reflexes**: A few beats of ankle clonus and an upgoing Babinski reflex may be normal.

6. **Moro (startle) reflex**: Hold the infant supine while supporting the head. Allow the head to drop 1–2 cm suddenly. The arms will abduct at the shoulder and extend at the elbow with spreading of the fingers. Adduction with flexion will follow. This reflex develops by 28 weeks' gestation (incomplete) and disappears by age 3 months.

7. **Tonic neck reflex**: Turn the infant's head to one side; the arm and leg on that side will extend while the opposite arm and leg flex ("fencing position"). This reflex disappears by age 8 months.


CARE OF THE WELL NEONATE

The primary responsibility of the Level 1 nursery is care of the well neonate—promoting mother-infant bonding, establishing feeding, and teaching the basics of newborn care. Staff must monitor infants for signs and symptoms of illness, including temperature instability, change in activity, refusal to feed, pallor, cyanosis, early or excessive jaundice, tachypnea, respiratory distress, delayed (beyond 24 hours) first stool or first void, and bilious vomiting. Several preventive measures are routine in the normal newborn nursery.

Prophylactic erythromycin ointment is applied to the eyes within 1 hour of birth to prevent gonococcal ophthalmia. Vitamin K (1 mg) is given intramuscularly or subcutaneously within 4 hours of birth to prevent hemorrhagic disease of the newborn.

All infants should receive hepatitis B vaccine. Both hepatitis B vaccine and hepatitis B immune globulin (HBIG) are administered if the mother is positive for hepatitis B surface antigen (HBsAg). If maternal HBsAg status is unknown, vaccine should be given before 12 hours of age, maternal blood should be tested for HBsAg, and HBIG should be given to the neonate before 7 days of age if the test is positive.
Cord blood is collected from all infants at birth and can be used for blood typing and Coombs testing if the mother is type O or Rh-negative to help assess the risk for development of jaundice.

Bedside glucose testing should be performed in infants at risk for hypoglycemia (infants of diabetic mothers, preterm, SGA, LGA, or stressed infants). Values below 45 mg/dL should be confirmed by laboratory blood glucose testing and treated. Hematocrit should be measured at age 3–6 hours in infants at risk for or those who have symptoms of polycythemia or anemia (see section on Hematologic Disorders).

State-sponsored newborn genetic screens (for inborn errors of metabolism such as phenylketonuria [PKU], galactosemia, sickle cell disease, hypothyroidism, congenital adrenal hyperplasia, and cystic fibrosis) are performed prior to discharge, after 24–48 hours of age if possible. In many states, a repeat test is required at 8–14 days of age because the PKU test may be falsely negative when obtained before 48 hours of age. Not all state-mandated screens include the same panel of diseases. The most recent additions include an expanded screen that tests for other inborn errors of metabolism such as fatty acid oxidation defects and amino or organic acid disorders and screening for severe combined immunodeficiency syndrome.

Infants should routinely be positioned supine to minimize the risk of sudden infant death syndrome (SIDS). Prone positioning is contraindicated unless there are compelling clinical reasons for that position. Bed sharing with adults, tobacco exposure, overheating, soft items in the bed and prone positioning are associated with increased risk of SIDS.

**FEEDING THE WELL NEONATE**

A neonate is ready for feeding if he or she is (1) alert and vigorous, (2) has no abdominal distention, (3) has good bowel sounds, and (4) has a normal hunger cry. These signs usually occur within 6 hours after birth, but fetal distress or traumatic delivery may prolong this period. The healthy full-term infant should be allowed to feed every 2–5 hours on demand. The first breast feeding may occur in the delivery room. For formula-fed infants, the first feeding usually occurs by 3 hours of life. The feeding volume generally increases from 0.5 to 1 oz per feeding initially to 1.5–2 oz per feeding on day 3. By day 3, the average full-term newborn takes about 100 mL/kg/d of milk.

A wide range of infant formulas satisfy the nutritional needs of most neonates. Breast milk is the standard on which formulas are based (see Chapter 11). Despite low concentrations of several vitamins and minerals in breast milk, bioavailability is high. All the necessary nutrients, vitamins, minerals, and water are provided by human milk for the first 6 months of life except vitamin K (1 mg IM is administered at birth), vitamin D (400 IU/d for all infants beginning shortly after birth), and vitamin B12 and zinc (if the mother is a strict vegetarian and takes no supplements). Other advantages of breast milk include (1) immunologic, antimicrobial, and anti-inflammatory factors such as immunoglobulin A (IgA) and cellular, protein, and enzymatic components that decrease the incidence of upper respiratory and gastrointestinal (GI) infections; (2) possible decreased frequency and severity of childhood eczema and asthma; (3) improved mother-infant bonding; and (4) improved neurodevelopmental outcome.

Although about 70% of mothers in the United States start by breast feeding, only 33% continue to do so at 6 months. Hospital practices that facilitate successful initiation of breast feeding include rooming-in, nursing on demand, and avoiding unnecessary supplemental formula. Nursery staff must be trained to recognize problems associated with breast feeding and provide help and support for mothers in the hospital. An experienced professional should observe and assist with several feedings to document good latch-on. Good latch-on is important in preventing the common problems of sore nipples, unsatisfied infants, breast engorgement, poor milk supply, and hyperbilirubinemia.

Table 2–4 presents guidelines the nursing mother and healthcare provider can use to assess successful breast feeding.

<table>
<thead>
<tr>
<th>First 8 h</th>
<th>First 8–24 h</th>
<th>Day 2</th>
<th>Day 3</th>
<th>Day 4</th>
<th>Day 5</th>
<th>Day 6 Onward</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milk supply</td>
<td>You may be able to express a few drops of milk.</td>
<td>Milk should come in between the second and fourth days.</td>
<td>Milk should be in. Breasts may be firm or leak milk.</td>
<td></td>
<td></td>
<td>Breasts should feel softer after feedings.</td>
</tr>
<tr>
<td>Baby’s activity</td>
<td>Baby is usually wide-awake in the first hour of life. Put baby to wake up your baby. Babies may not wake up on their own to feed.</td>
<td>Baby should be more cooperative and less sleepy.</td>
<td>Look for early feeding cues such as rooting, lip smacking, and hands to face.</td>
<td></td>
<td></td>
<td>Baby should appear satisfied after feedings.</td>
</tr>
<tr>
<td>First 8 h</td>
<td>First 8–24 h</td>
<td>Day 2</td>
<td>Day 3</td>
<td>Day 4</td>
<td>Day 5</td>
<td>Day 6 Onward</td>
</tr>
<tr>
<td>-----------</td>
<td>--------------</td>
<td>-------</td>
<td>-------</td>
<td>-------</td>
<td>-------</td>
<td>-------------</td>
</tr>
<tr>
<td>breast within 30 min after birth.</td>
<td>Use chart to write down time of each feeding.</td>
<td>Feed your baby every 1–4 h or as often as wanted—at least 8–12 times a day.</td>
<td></td>
<td></td>
<td></td>
<td>May go one longer interval (up to 5 h between feeds) in a 24-h period.</td>
</tr>
<tr>
<td>Baby may go into a deep sleep 2–4 h after birth.</td>
<td></td>
<td></td>
<td>Consider hand expressing or pumping a few drops of milk to soften the nipple if the breast is too firm for the baby to latch on.</td>
<td></td>
<td></td>
<td>Nurse a minimum of 10–30 min per side every feeding for the first few weeks of life.</td>
</tr>
<tr>
<td>Baby will wake up and be alert and responsive for several more hours after initial deep sleep.</td>
<td>As long as the mother is comfortable, nurse at both breasts as long as baby is actively sucking.</td>
<td>Try to nurse both sides each feeding, aiming at 10 min per side. Expect some nipple tenderness.</td>
<td></td>
<td></td>
<td>Once milk supply is well established, allow baby to finish the first breast before offering the second.</td>
<td></td>
</tr>
<tr>
<td>Baby's urine output</td>
<td>Baby must have a minimum of one wet diaper in the first 24 h.</td>
<td>Baby must have at least one wet diaper every 8–11 h.</td>
<td>You should see an increase in wet diapers (up to four to six) in 24 h.</td>
<td></td>
<td></td>
<td>Baby should have six to eight wet diapers per day of colorless or light yellow urine.</td>
</tr>
<tr>
<td>Baby's stool</td>
<td>Baby may have a very dark (meconium) stool.</td>
<td>Baby may have a stool second very dark (meconium) stool.</td>
<td>Baby's stools should be in transition from black-green to yellow.</td>
<td></td>
<td></td>
<td>Baby should have three or four yellow, seedy stools a day.</td>
</tr>
<tr>
<td>Mother's nipple tenderness is improving or is gone.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>The number of stools may decrease gradually after 4–6 wk.</td>
</tr>
</tbody>
</table>

Modified, with permission, from Gabrielski L: Lactation support services. Childrens Hospital Colorado; 1999.

EARLY DISCHARGE OF THE NEWBORN INFANT

Discharge at 24–36 hours of age is safe and appropriate for some newborns if there are no contraindications (Table 2–5) and if a follow-up visit within 48 hours is ensured. Most infants with cardiac, respiratory, or infectious disorders are identified in the first 12–24 hours of life. The exception may be the infant treated intrapartum with antibiotic prophylaxis for maternal group B streptococcal (GBS) colonization or infection. The Centers for Disease Control and Prevention (CDC) and the American Academy of Pediatrics (AAP) recommend that such infants be observed in hospital for 48 hours if they received no or inadequate intrapartum antibiotic prophylaxis (< 4 hours prior to delivery, or drug other than ampicillin, penicillin, or cefazolin). Hospital observation beyond 24 hours may not be necessary for well-appearing full-term infants who received adequate intrapartum chemoprophylaxis (penicillin, ampicillin, or cefazolin ≥ 4 hours prior to delivery), and for whom ready access to medical care can be ensured if needed. Other problems, such as jaundice and breast-feeding problems, typically occur after 48 hours and can usually be dealt with on an outpatient basis.

Table 2–5. Contraindications to early newborn discharge.

Contraindications to early newborn discharge

1. Jaundice ≤ 24 h
2. High risk for infection (eg, maternal chorioamnionitis); discharge allowed after 24 h with a normal transition
3. Known or suspected narcotic addiction or withdrawal
4. Physical defects requiring evaluation
5. Oral defects (clefts, micrognathia)

Relative contraindications to early newborn discharge (infants at high risk for feeding failure, excessive jaundice)

1. Prematurity or early term infant (< 38 weeks' gestation)
2. Birth weight < 2700 g (6 lb)
3. Infant difficult to arouse for feeding; not demanding regularly in nursery
4. Medical or neurologic problems that interfere with feeding (Down syndrome, hypotonia, cardiac problems)
5. Twins or higher multiples
6. ABO blood group incompatibility or severe jaundice in previous child
7. Mother whose previous breast-fed infant gained weight poorly
8. Mother with breast surgery involving periareolar areas (if attempting to nurse)

The AAP recommends a follow-up visit within 48 hours for all newborns discharged before 72 hours of age. Infants who are small or late preterm—especially if breast feeding—are at particular risk for inadequate intake; the early visit is especially important for these infants. Suggested guidelines for the follow-up interview and physical examination are presented in Table 2–6. The optimal timing of discharge must be determined in each case based on medical, social, and financial factors.

Table 2–6. Guidelines for early outpatient follow-up evaluation.

- History
  - Rhythmic sucking and audible swallowing for at least 10 min total per feeding?
  - Infant wakes and demands to feed every 2–3 h (at least 8–10 feedings per 24 h)?
  - Do breasts feel full before feedings, and softer after?
  - Are there at least 6 noticeably wet diapers per 24 h?
  - Are there yellow bowel movements (no longer meconium)—at least 4 per 24 h?
- Is infant still acting hungry after nursing (frequently sucks hands, rooting)?

**Physical assessment**

- Weight, unclad: should not be more than 8%–10% below birth weight
- Extent and severity of jaundice
- Assessment of hydration, alertness, general well-being
- Cardiovascular examination: murmurs, brachial and femoral pulses, respirations

**CIRCUMCISION**

Circumcision is an elective procedure to be performed only in healthy, stable infants. The procedure has medical benefits, including prevention of phimosis, paraphimosis, balanoposthitis, and urinary tract infection. Important later benefits of circumcision include decreased incidence of penile cancer, decreased incidence of sexually transmitted diseases (including HIV), and decreased incidence of cervical cancer in female sexual partners. Most parental decisions regarding circumcision are religious and social, not medical. The risks of circumcision include local infection, bleeding, removal of too much skin, and urethral injury. The combined incidence of complications is less than 1%. Local anesthesia by dorsal penile nerve block or circumferential ring block using 1% lidocaine without epinephrine, or topical anesthetic cream are safe and effective methods that should always be used. Techniques allowing visualization of the glans throughout the procedure (Plastibell and Gomco clamp) are preferred to blind techniques (Mogen clamp) as occasional amputation of the glans occurs with the latter technique. Circumcision is contraindicated in infants with genital abnormalities (eg, hypospadias). A coagulation screen should be performed prior to the procedure in infants with a family history of serious bleeding disorders.

**HEARING SCREENING**

Normal hearing is critical to normal language development. Significant bilateral hearing loss is present in 1–3 infants per 1000 well neonates and in 2–4 per 100 neonates in the intensive care unit population. Infants should be screened for hearing loss by auditory brainstem evoked responses or evoked otoacoustic emissions as early as possible because up to 40% of hearing loss will be missed by risk analysis alone. Primary care providers and parents should be advised of the possibility of hearing loss and offered immediate referral in suspect cases. With the use of universal screening, the average age at which hearing loss is confirmed has dropped from 24–30 months to 2–3 months. If remediation is begun by 6 months, language and social development are commensurate with physical development.


**COMMON PROBLEMS IN THE TERM NEWBORN**

**NEONATAL JAUNDICE**

General Considerations
Sixty-five percent of newborns develop visible jaundice with a total serum bilirubin (TSB) level higher than 6 mg/dL during the first week of life. Bilirubin, a potent antioxidant and peroxyl scavenger, may protect the normal newborn, who is deficient in antioxidants such as vitamin E, catalase, and super-oxide dismutase, from oxygen toxicity in the first days of life. Approximately 8%–10% of newborns develop excessive hyperbilirubinemia (TSB > 17 mg/dL), and 1%–2% have TSB above 20 mg/dL. Extremely high and potentially dangerous TSB levels are rare. Approximately 1 in 700 infants have TSB higher than 25 mg/dL, and 1 in 10,000 have TSB above 30 mg/dL. Such high levels can cause kernicterus, characterized by injury to the basal ganglia and brainstem.

Kernicterus caused by hyperbilirubinemia was common in neonates with Rh-isoimmunization until the institution of exchange transfusion for affected infants and postpartum high-titer Rho (D) immune globulin treatment to prevent sensitization of Rh-negative mothers. For several decades after the introduction of exchange transfusion and phototherapy aimed at keeping the neonate's TSB below 20 mg/dL, there were no reported cases of kernicterus in the United States. Since the early 1990s, however, there has been a reappearance of kernicterus, with more than 120 cases reported. Common factors in the recent cases are newborn discharge before 48 hours, breast feeding, delayed measurement of TSB, unrecognized hemolysis, lack of early post discharge follow-up, and failure to recognize the early symptoms of bilirubin encephalopathy.

Bilirubin is produced by the breakdown of heme (iron protoporphyrin) in the reticuloendothelial system and bone marrow. Heme is cleaved by heme oxygenase to iron, which is conserved; carbon monoxide, which is exhaled; and biliverdin, which is converted to bilirubin by bilirubin reductase. Each gram of hemoglobin yields 34 mg of bilirubin (1 mg/dL = 17.2 mmol/L of bilirubin). This unconjugated bilirubin is bound to albumin and carried to the liver, where it is taken up by hepatocytes. In the presence of the enzyme uridyldiphosphoglucuronyl transferase (UDPGT; glucuronyl transferase), bilirubin is conjugated to one or two glucuronide molecules. Conjugated bilirubin is then excreted through the bile to the intestine. In the presence of normal gut flora, conjugated bilirubin is metabolized to stercobilins and excreted in the stool. Absence of gut flora and slow GI motility, both characteristics of the newborn, cause stasis of conjugated bilirubin in the intestinal lumen, where mucosal β-glucuronidase removes the glucuronide molecules and leaves unconjugated bilirubin to be reabsorbed (enterohepatic circulation).

Excess accumulation of bilirubin in blood depends on both the rate of bilirubin production and the rate of excretion. It is best determined by reference to an hour-specific TSB level above the 95th percentile for age in hours (Figure 2–2).

1. Physiologic Jaundice

ESSENTIALS OF DIAGNOSIS & TYPICAL FEATURES

- Visible jaundice appearing after 24 h of age.
- Total bilirubin rises by < 5 mg/dL (86 mmol/L) per day.
- Peak bilirubin occurs at 3–5 d of age, with a total bilirubin of no more than 15 mg/dL (258 mmol/L).
- Visible jaundice resolves by 1 wk in the full-term infant and by 2 wk in the preterm infant.

Factors contributing to physiologic jaundice in neonates include low UDPGT activity, relatively high red cell mass, absence of intestinal flora, slow intestinal motility, and increased enterohepatic circulation of bilirubin in the first days of life. Hyperbilirubinemia outside of the ranges noted in Figure 2–2 is not physiologic and requires further evaluation.

2. Pathologic Unconjugated Hyperbilirubinemia

Pathologic unconjugated hyperbilirubinemia can be grouped into two main categories: overproduction of bilirubin or decreased conjugation of bilirubin (Table 2–7). The TSB is a reflection of the balance between these processes. Visible jaundice with a TSB greater than 5 mg/dL before 24 hours of age is most commonly a result of significant hemolysis.

Table 2–7. Causes of pathologic unconjugated hyperbilirubinemia.

**Overproduction of bilirubin**

1. Hemolytic causes of increased bilirubin production (reticulocyte count elevated)
   a. Immune-mediated: positive direct antibody (DAT, Coombs) test
      - ABO blood group incompatibility, Rh incompatibility, minor blood group antigen incompatibility
   b. Nonimmune: negative direct antibody (DAT, Coombs) test
      - Abnormal red cell shapes: spherocytosis, elliptocytosis, pyknocytosis, stomatocytosis
      - Red cell enzyme abnormalities: glucose-6-phosphate dehydrogenase deficiency, pyruvate kinase deficiency, hexokinase deficiency, other metabolic defects
   c. Patients with bacterial or viral sepsis
2. Nonhemolytic causes of increased bilirubin production (reticulocyte count normal)
   a. Extravascular hemorrhage: cephalohematoma, extensive bruising, intracranial hemorrhage
   b. Polycythemia
   c. Exaggerated enterohepatic circulation of bilirubin: bowel obstruction, functional ileus
   d. Breast feeding–associated jaundice (inadequate intake of breast milk causing exaggerated enterohepatic circulation of bilirubin)

**Decreased rate of conjugation**

1. Crigler-Najjar syndrome (rare, severe)
   a. Type I glucuronyl transferase deficiency, autosomal-recessive
   b. Type II glucuronyl transferase deficiency, autosomal-dominant
2. Gilbert syndrome (common, milder)
3. Hypothyroidism
A. Increased Bilirubin Production

Increased bilirubin production is caused by excessive destruction of neonatal red blood cells. Destruction may be mediated by maternal antibodies (Coombs test–positive), or may be due to abnormal red cell membranes (spherocytosis), or abnormal red cell enzymes (glucose-6-phosphate dehydrogenase [G6PD] deficiency) causing decreased red cell life span not mediated by antibodies. Antibodies can be directed against the major blood group antigens (type A or type B infant of a type O mother); the antigens of the Rh-system (D, E, C, d, e, c); and Kell, Duffy, and other antigens.

1. Antibody-mediated hemolysis (Coombs test–positive)

a. ABO blood group incompatibility

This finding can accompany any pregnancy in a type O mother. Hemolysis is usually mild, but the severity is unpredictable because of variability in the amount of naturally occurring maternal anti-A or anti-B IgG antibodies. Although 20% of pregnancies are "set-ups" for ABO incompatibility (mother O, infant A or B), only 33% of infants in such cases have a positive direct Coombs test and only 20% of these develop jaundice that requires therapy. Since maternal antibodies may persist for several months after birth, the newborn may become progressively more anemic over the first few weeks of life, occasionally to the point of requiring transfusion.

b. rh-isoimmunization

This hemolytic process is less common, more severe, and more predictable than ABO incompatibility. The severity increases with each immunized pregnancy because of an anamnestic maternal IgG antibody response. Most Rh-disease can be prevented by giving high-titer Rho (D) immune globulin to the Rh-negative woman after invasive procedures during pregnancy or after miscarriage, abortion, or delivery of an Rh-positive infant. Affected neonates are often anemic at birth, and continued hemolysis rapidly causes hyperbilirubinemia and more severe anemia. The most severe form of Rh-isoimmunization, erythroblastosis fetalis, is characterized by life-threatening anemia, generalized edema, and fetal or neonatal heart failure. Without antenatal intervention, fetal or neonatal death often results. The cornerstone of antenatal management is transfusion of the fetus with Rh-negative cells, either directly into the umbilical vein or into the fetal abdominal cavity. Phototherapy is usually started in these infants upon delivery, with exchange transfusion frequently needed. Intravenous immune globulin (IVIG; 0.5–1 g/kg) given to the infant as soon as the diagnosis is made may decrease the need for exchange transfusion. Ongoing hemolysis occurs until all maternal antibodies are gone; therefore, these infants require monitoring for 2–3 months for recurrent anemia severe enough to require transfusion.

2. Nonimmune hemolysis (Coombs test–negative)

a. hereditary spherocytosis

This condition is the most common of the red cell membrane defects and causes hemolysis by decreasing red cell deformability. Affected infants may have hyperbilirubinemia severe enough to require exchange transfusion. Splenomegaly may be present. Diagnosis is suspected by peripheral blood smear and family history. See Chapter 30 for a more in-depth discussion.

b. G6PD deficiency

This condition is the most common red cell enzyme defect causing hemolysis, especially in infants of African, Mediterranean, or Asian descent. Onset of jaundice is often later than in isimmune hemolytic disease, toward 1 week of age. The role of G6PD deficiency in neonatal jaundice is probably underestimated as up to 10%–13% of African Americans are G6PD-deficient. Although the disorder is X-linked, female heterozygotes are also at increased risk of hyperbilirubinemia due to X-chromosome inactivation. In most cases, no triggering agent for hemolysis is found in the newborn. Rather, some infants who develop severe jaundice with G6PD deficiency have been found also to have Gilbert syndrome (see below). Their increased bilirubin production is further exaggerated by a decreased rate of bilirubin conjugation. Since G6PD enzyme activity is high in reticulocytes, neonates with a large number of reticulocytes may have falsely normal enzyme tests. A low G6PD level should always raise suspicions. Repeat testing in suspect cases with initially normal results is indicated at 2–3 months of age. Please also see Chapter 30 for more details.

3. Nonhemolytic increased bilirubin production

Enclosed hemorrhage, such as cephalohematoma, intracranial hemorrhage, or extensive bruising in the skin, can lead to jaundice. Polycythemia leads to jaundice by increased red cell mass, with increased numbers of cells reaching senescence daily. Bowel obstruction, functional or mechanical, leads to an increased enterohepatic circulation of bilirubin.
B. Decreased Rate of Conjugation

1. UDPGT deficiency: Crigler-Najjar syndrome type I (complete deficiency, autosomal recessive) and type II (partial deficiency, autosomal dominant)

These rare conditions result from mutations in the exon or encoding region of the UDPGT gene that cause complete or nearly complete absence of enzyme activity. Both can cause severe unconjugated hyperbilirubinemia, bilirubin encephalopathy, and death if untreated. In type II, the enzyme can be induced with [phenobarbital](http://accesspediatrics.mhmedical.com/content.aspx?bookid=1016&sectionid...), which may lower bilirubin levels by 30%–80%. Liver transplantation is curative.

2. Gilbert syndrome

This is a common mild autosomal dominant disorder characterized by decreased hepatic UDPGT activity caused by genetic polymorphism at the promoter region of the UDPGT gene. Approximately 9% of the population is homozygous, and 42% is heterozygous for this abnormality, with a gene frequency of 0.3. Affected individuals tend to develop hyperbilirubinemia in the presence of conditions that increase bilirubin load, including G6PD deficiency. They are also more likely to have prolonged neonatal jaundice and breast-milk jaundice.

C. Hyperbilirubinemia Caused by Unknown or Multiple Factors

1. Racial differences

Asians (23%) are more likely than whites (10%–13%) or African Americans (4%) to have a peak neonatal TSB greater than 12 mg/dL (206 mmol/L). It is likely that these differences result from racial variations in prevalence of UDPGT gene polymorphisms or associated G6PD deficiency.

2. Prematurity

Premature infants often have poor enteral intake, delayed stooling, and increased enterohepatic circulation, as well as a shorter red cell life. Infants at 35–36 weeks' gestation are 13 times more likely than term infants to be readmitted for hyperbilirubinemia. Even early-term infants (37–38 weeks' gestation) are four times more likely than term neonates to have TSB greater than 13 mg/dL (224 mmol/L).

3. Breast feeding and jaundice

a. breast-milk jaundice

Unconjugated hyperbilirubinemia lasting until 2–3 months of age is common in breast-fed infants. An increased prevalence of the Gilbert syndrome promoter polymorphism may be involved. Moderate unconjugated hyperbilirubinemia for 6–12 weeks in a thriving breast-fed infant without evidence of hemolysis, hypothyroidism, or other disease strongly suggests this diagnosis.

b. breast feeding–associated jaundice

This common condition has also been called "lack-of-breast-milk" jaundice. Breast-fed infants have a higher incidence (9%) of unconjugated serum bilirubin levels greater than 13 mg/dL (224 mmol/L) than do formula-fed infants (2%) and are more likely to have TSB greater than 15 mg/dL (258 mmol/L) than formula-fed infants (2% vs 0.3%). The pathogenesis is probably poor enteral intake and increased enterohepatic circulation. There is no apparent increase in bilirubin production as measured by carbon monoxide exhalation. Although rarely severe enough to cause bilirubin encephalopathy, nearly 100% of the infants with kernicterus reported over the past 20 years were exclusively breast fed, and in 50%, breast feeding was the only known risk factor. Excessive jaundice should be considered a possible sign of failure to establish an adequate milk supply, and should prompt specific inquiries (Table 2–8). If intake is inadequate, the infant should receive supplemental formula and the mother should be instructed to nurse more frequently and to use an electric breast pump every 2 hours to enhance milk production. Consultation with a lactation specialist should be considered. Because hospital discharge of normal newborns occurs before the milk supply is established and before jaundice peaks, a follow-up visit 2 days after discharge is recommended by the AAP to evaluate adequacy of intake and degree of jaundice.

Table 2–8. Signs of inadequate breast-milk intake.

<table>
<thead>
<tr>
<th>Weight loss of &gt; 8%–10% from birth</th>
</tr>
</thead>
</table>

Fewer than six noticeably wet diapers per 24 h by day 3–4
Fewer than four stools per day, or still meconium, by day 3–4
Nursing fewer than eight times per 24 h, or for less than 10 min each feeding

3. Bilirubin Toxicity

Unconjugated bilirubin anion is the agent of bilirubin neurotoxicity. The anion binds to the phospholipids (gangliosides) of neuronal plasma membranes causing injury, which then allows more anion to enter the neuron. Intracellular bilirubin anion binds to the membrane phospholipids of subcellular organelles, causing impaired energy metabolism and cell death. The blood-brain barrier undoubtedly has a role in protecting the infant from brain damage, but its integrity is impossible to measure clinically. The amount of albumin available to bind the unconjugated bilirubin anion and the presence of other anions that may displace bilirubin from albumin-binding sites are also important. It is unknown whether there is a fixed level of bilirubin above which brain damage always occurs. The term kernicterus describes the pathologic finding of staining of basal ganglia and brainstem nuclei, as well as the clinical syndrome of chronic brain injury due to hyperbilirubinemia. The term acute bilirubin encephalopathy describes the signs and symptoms of evolving brain injury in the newborn.

The risk of bilirubin encephalopathy is small in healthy, term neonates even at bilirubin levels of 25–30 mg/dL (430–516 mmol/L). Risk depends on the duration of hyperbilirubinemia, the concentration of serum albumin, associated illness, acidosis, and the concentrations of competing anions such as sulfisoxazole and ceftriaxone. Premature infants are at greater risk than term infants because of the greater frequency of associated illness affecting the integrity of the blood-brain barrier, reduced albumin levels, and decreased affinity of albumin-binding sites. For these reasons, the "exchange level" (the level at which bilirubin encephalopathy is thought likely to occur) in premature infants may be lower than that of a term infant.

4. Acute Bilirubin Encephalopathy

ESSENTIALS OF DIAGNOSIS & TYPICAL FEATURES

- Lethargy, poor feeding.
- Irritability, high-pitched cry.
- Arching of the neck (retrocollis) and trunk (opisthotonos).
- Apnea, seizures, coma (late).

Newborn infants with evolving acute bilirubin encephalopathy may be described as "sleepy and not interested in feeding." Although these symptoms are nonspecific, they are also the earliest signs of acute bilirubin encephalopathy and should trigger, in the jaundiced infant, a detailed evaluation of the birth and postnatal history, feeding and elimination history, an urgent assessment for signs of bilirubin-induced neurologic dysfunction (BIND), and a TSB and albumin measurement. A scoring system has been proposed (Table 2–9) to monitor the severity and progression of bilirubin encephalopathy. A score of 4–6 indicates progressive encephalopathy likely to be reversible with aggressive treatment, whereas a score of 7–9 represents advanced and possibly irreversible damage.

Table 2–9. BIND scoring system.

<table>
<thead>
<tr>
<th>1 Point (Nonspecific, Subtle)</th>
<th>2 Points (Progressive Toxicity)</th>
<th>3 Points (Advanced Toxicity)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mental status</td>
<td>Sleepy, poor feeding</td>
<td>Lethargy + irritability</td>
</tr>
<tr>
<td>Muscle tone</td>
<td>Slight decrease</td>
<td>Hypertonia or hypotonia, depending on arousal state or Mild arching Shril</td>
</tr>
<tr>
<td>Cry</td>
<td>High-pitched</td>
<td></td>
</tr>
</tbody>
</table>

BIND, bilirubin-induced neurologic dysfunction.

Correlation between TSB level and neurotoxicity is poor. Although 65% of recently reported cases of kernicterus had TSB levels above 35 mg/dL, 15% had levels below 30 mg/dL, and 8% were below 25 mg/dL. Measurement of free, unbound, unconjugated bilirubin (B\textsubscript{f}) may be a more meaningful predictor of risk for brain injury, although this test is not yet clinically available. Currently the most sensitive means of assessing neurotoxicity may be the auditory brainstem evoked response, which shows predictable, early effects of bilirubin toxicity.

5. Chronic Bilirubin Encephalopathy (Kernicterus)

ESSENTIALS OF DIAGNOSIS & TYPICAL FEATURES

- Extrapyramidal movement disorder (choreoathetoid cerebral palsy).
- Gaze abnormality, especially limitation of upward gaze.
- Auditory disturbances (deafness, failed auditory brainstem evoked response with normal evoked otoacoustic emissions, auditory neuropathy, auditory dyssynchrony).
- Dysplasia of the enamel of the deciduous teeth.

Kernicterus is an irreversible brain injury characterized by choreoathetoid cerebral palsy and hearing impairment. Intelligence is probably normal but may be difficult to assess because of associated hearing, communication, and coordination problems. The diagnosis is clinical but is strengthened if audiologic testing shows auditory neuropathy and auditory dyssynchrony in which the otoacoustic emission test is normal but the auditory brainstem response is absent. Infants with such findings are usually deaf. Infants with milder kernicterus may have normal audiograms but abnormal auditory processing and subsequent problems with speech comprehension. Magnetic resonance imaging (MRI) scanning of the brain is nearly diagnostic if it shows abnormalities isolated to the globus pallidus or the subthalamic nuclei, or both.

Evaluation of Hyperbilirubinemia

Because most newborns are discharged at 24–48 hours of age, before physiologic jaundice peaks and before maternal milk supply is established, a predischarge TSB or a transcutaneous bilirubin measurement (TcB) may help predict which infants are at risk for severe hyperbilirubinemia. In all infants, an assessment of risk for severe hyperbilirubinemia should be performed before discharge (Table 2–10). As recommended by the AAP, follow-up within 24–48 hours for all infants discharged before 72 hours of age (depending on the number of risk factors present) is imperative. Although jaundice is usually visible above a TSB level of 5 mg/dL (86 mmol/L), visual estimation of the bilirubin level is inaccurate. TSB should be measured and interpreted based on the age of the infant in hours at the time of sampling. Term infants with a TSB level greater than the 95th percentile for age in hours have a 40% risk of developing significant hyperbilirubinemia (see Figure 2–2). Serial bilirubin levels should be obtained from a single laboratory whenever possible to make interpretation of serial measurements more meaningful. It is important to remember that these nomograms apply only to early-term and full-term infants, 36 weeks and older.

Table 2–10. Factors affecting the risk of severe hyperbilirubinemia in infants 35 or more weeks' gestation (in approximate order of importance).

- **Major risk factors**
  - Predischarge TSB or TcB level in the high-risk zone (> 95th percentile; see Figure 2–2)
  - Jaundice observed in the first 24 h
  - Blood group incompatibility with positive direct Coombs test, other known hemolytic disease (eg, G6PD deficiency), or elevated ETCO
  - Gestational age 35–36 wk
  - Previous sibling required phototherapy
  - Cephalohematoma or significant bruising
• Exclusive breast feeding, particularly if weight loss is excessive
• East Asian race\textsuperscript{a}

**Minor risk factors**

• Predischarge TSB or TcB level in the high-intermediate-risk zone (75–95th percentile)
• Gestational age 37–38 wk
• Jaundice observed before discharge
• Previous sibling with jaundice
• Macrosomic infant of a diabetic mother

**Decreased risk (these factors are associated with decreased risk of significant jaundice, listed in order of decreasing importance)**

• TSB or TcB level in the low-risk zone (see Figure 2–2)
• Gestational age ≥ 41 wk
• Exclusive bottle feeding
• Black race\textsuperscript{a}
• Discharge from hospital after 72 h

ETCO, end-tidal carbon monoxide; G6PD, glucose-6-phosphate dehydrogenase; TcB, transcutaneous bilirubin; TSB, total serum bilirubin.

\textsuperscript{a}Race as defined by mother's description.

Infants with visible jaundice on the first day of life or who develop excessive jaundice require further evaluation. The minimal evaluation consists of the following:

• Feeding and elimination history.
• Birth weight and percent weight change since birth.
• Examination for sources of excessive heme breakdown.
• Assessment of blood type, Coombs testing, complete blood count (CBC) with smear, serum albumin, and TSB.
• G6PD test if jaundice is otherwise unexplained, and in African-American infants with severe jaundice.
• Fractionated bilirubin level in infants who appear ill, those with prolonged jaundice, acholic stool, hepatosplenomegaly, or dark urine.

**Treatment of Indirect Hyperbilirubinemia**

A. **Phototherapy**

Phototherapy is the most common treatment for indirect hyperbilirubinemia. It is relatively noninvasive and safe. Light of wavelength 425–475 nm (blue-green spectrum) is absorbed by unconjugated bilirubin in the skin converting it to a water-soluble stereoisomer that can be excreted in bile without conjugation. The minimum effective light dose is 10–14 μW/cm\textsuperscript{2} irradiance. Intensive phototherapy employs irradiance of 30 μW/cm\textsuperscript{2} or higher. Irradiance can be increased by increasing the exposed body surface area or by moving the light source closer to the infant. Fiberoptic blankets are useful as adjuncts but are not adequate as sole therapy for term infants because they do not cover sufficient surface area. Intensive phototherapy should decrease TSB by 30%–40% in the first 24 hours, most significantly in the first 4–6 hours. The infant's
eyes should be shielded to prevent retinal damage. Diarrhea, which sometimes occurs during phototherapy, can be treated if necessary by feeding a nonlactose-containing formula.

Phototherapy is started electively when the TSB is approximately 6 mg/dL (102 mmol/L) lower than the predicted exchange level for that infant (eg, at 16–19 mg/dL [272–323 mmol/L]) for a full-term infant for whom exchange transfusion would be considered at a TSB of approximately 22–25 mg/dL [374–425 mmol/L]). AAP guidelines for phototherapy and exchange transfusion in infants of 35 or more weeks' gestation are shown in Figures 2–3 and 2–4. Hyperbilirubinemic infants should be fed by mouth if possible to decrease enterohepatic bilirubin circulation. Casein hydrolysate formula to supplement breast milk decreases enterohepatic circulation by inhibiting mucosal β-glucuronidase activity. IVIG (0.5–1.0 g/kg) in severe antibody-mediated hemolysis may interrupt the hemolytic process. Although phototherapy has been shown to decrease the need for exchange transfusion, its long-term benefits, if any, in infants with less severe jaundice are unknown.

Figure 2–3. Guidelines for phototherapy in hospitalized infants of 35 or more weeks' gestation. These guidelines are based on limited evidence and levels shown are approximations. The guidelines refer to the use of intensive phototherapy (at least 30 μW/cm² in the blue-green spectrum), which should be used when the total serum bilirubin (TSB) exceeds the line indicated for each category. If TSB approaches the exchange level, the sides of the incubator or bassinet should be lined with aluminum foil or white material. (Reproduced, with permission, from the AAP Subcommittee on Hyperbilirubinemia: Management of hyperbilirubinemia in the newborn infant 35 or more weeks of gestation. Pediatrics 2004;114:297.)

Figure 2–4. Guidelines for exchange transfusion in infants of 35 or more weeks' gestation. These guidelines represent approximations for which an exchange transfusion is indicated in infants treated with intensive phototherapy. For readmitted infants, if the total serum bilirubin (TSB) level is above the exchange level, repeat TSB measurement every 2–3 hours and consider exchange if the TSB remains above the level after 6 hours of intensive phototherapy. The total serum bilirubin/albumin ratio (TSB [mg/dL]/Alb [g/dL]; 8.0 for infants at lower risk, 7.2 for medium risk, and 6.8 for higher risk) can be used together with, but not in lieu of the TSB level as an additional factor in determining the need for transfusion. If the TSB is at or approaching exchange level, send blood for an immediate type and crossmatch. (Reproduced, with permission, from the AAP Subcommittee on Hyperbilirubinemia: Management of hyperbilirubinemia in the newborn infant 35 or more weeks of gestation. Pediatrics 2004;114:297.)
B. Exchange Transfusion

Although most infants with indirect hyperbilirubinemia can be treated with phototherapy, extreme indirect hyperbilirubinemia is a medical emergency. Infants should be admitted at once to a neonatal intensive care unit where exchange transfusion can be performed before irreversible neurologic damage occurs. Intensive phototherapy should be instituted immediately, during transport to the hospital if possible. As TSB nears the potentially toxic range, serum albumin should be determined. Albumin (1 g/kg) will aid in binding and removal of bilirubin during exchange transfusion, as well as afford some neuroprotection while preparing for the procedure. Table 2–11 illustrates the bilirubin/albumin ratios at which exchange transfusion should be considered.

Table 2–11. Additional guidelines for exchange transfusion: effects of albumin.

<table>
<thead>
<tr>
<th>Risk Category</th>
<th>Bilirubin/Albumin Ratio at Which to Consider Exchange Transfusion (TSB [mg/dL]:Albumin [g/dL])</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infants &gt; 38 wk and well</td>
<td>8.0</td>
</tr>
<tr>
<td>Infants 35–38 wk and well, or &gt; 38 wk with higher risk (hemolysis, G6PD deficiency, sepsis, acidosis)</td>
<td>7.2</td>
</tr>
<tr>
<td>Infants 35–38 wk with higher risk, as above</td>
<td>6.8</td>
</tr>
</tbody>
</table>

G6PD, glucose-6-phosphate dehydrogenase; TSB, total serum bilirubin.

Double-volume exchange transfusion (approximately 160–200 mL/kg body weight) is most often required in infants with extreme hyperbilirubinemia secondary to Rh isoimmunization, ABO incompatibility, or hereditary spherocytosis. The procedure decreases serum bilirubin acutely by approximately 50% and removes about 80% of sensitized or abnormal red blood cells and offending antibody so that ongoing hemolysis is decreased. Exchange transfusion is also indicated in any infant with TSB above 30 mg/dL, in infants with signs of encephalopathy, or when intensive phototherapy has not lowered TSB by at least 0.5 mg/dL/h after 4 hours. The decision to perform exchange transfusion should be based on TSB, not on the indirect fraction of bilirubin.

Exchange transfusion is invasive, potentially risky, and infrequently performed. It should therefore be performed at a referral center. Mortality is 1%–5% and is greatest in the smallest, most immature, and unstable infants. Sudden death during the procedure can occur in any infant. There is a 5%–10% risk of serious complications such as necrotizing enterocolitis (NEC), infection, electrolyte disturbances, or thrombocytopenia. Isovolemic exchange (withdrawal through an arterial line with infusion through a venous line) may decrease the risk of some complications.
C. Protoporphyrins

Tin and zinc protoporphyrin or mesoporphyrin (Sn-PP, Zn-PP; Sn-MP, Zn-MP) are inhibitors of heme oxygenase, the enzyme that initiates the catabolism of heme (iron protoporphyrin). Studies are underway involving a single injection of these substances shortly after birth to prevent the formation of bilirubin. Although results are promising, these drugs are not yet approved for use in the United States.


HYPOGLYCEMIA

ESSENTIALS OF DIAGNOSIS & TYPICAL FEATURES

• Blood glucose < 40 mg/dL at birth to 4 h, or < 45 mg/dL at 4–24 h of age.

• LGA, SGA, preterm, and stressed infants at risk.

• May be asymptomatic.

• Infants can present with lethargy, poor feeding, irritability, or seizures.

General Considerations

Blood glucose concentration in the fetus is approximately 15 mg/dL less than maternal glucose concentration. Glucose concentration decreases in the immediate postnatal period, to as low as 30 mg/dL in many healthy infants at 1–2 hours after birth. Concentrations below 40 mg/dL after the first feeding are considered hypoglycemic. By 3 hours, the glucose concentration in normal full-term infants stabilizes at ≥ 45 mg/dL. The two groups of full-term newborn infants at highest risk for hypoglycemia are infants of diabetic mothers (IDMs) and IUGR infants.

A. Infants of Diabetic Mothers

The infant of a diabetic mother (IDM) has abundant glucose stores in the form of glycogen and fat but develops hypoglycemia because of hyperinsulinemia induced by maternal and fetal hyperglycemia. Increased energy supply to the fetus from the maternal circulation results in a macrosomic infant. The large infant is at increased risk for trauma during delivery. Some infants have cardiomyopathy (asymmetrical septal hypertrophy) which may present with murmur, respiratory distress, or cardiac failure. Microcolon is occasionally present in IDMs and causes symptoms of low intestinal obstruction similar to Hirschsprung disease. Other neonatal problems include hypercoagulability and polycythemia, a
combination that predisposes the infant to large vein thromboses (especially the renal vein). IDMs are often somewhat immature for their gestational age and are at increased risk for surfactant deficiency, hypocalcemia, feeding difficulties, and hyperbilirubinemia. Infants of mothers who were diabetic at conception have a higher incidence of congenital anomalies, probably related to first-trimester glucose control.

B. Intrauterine Growth-Restricted Infants

The intrauterine growth-restricted (IUGR) infant has reduced glucose stores in the form of glycogen and body fat and is prone to hypoglycemia. In addition, marked hyperglycemia and a transient diabetes mellitus–like syndrome occasionally develop, particularly in the very premature IUGR infant. These problems usually respond to adjustment in glucose intake, although insulin is sometimes needed transiently. Some IUGR infants have hyperinsulinemia that persists for a week or more.

C. Other Causes of Hypoglycemia

Hypoglycemia occurs in disorders with islet cell hyperplasia including the Beckwith-Wiedemann syndrome, nesidioblastosis, and other genetic forms of hyperinsulinism. Hypoglycemia also occurs in certain inborn errors of metabolism such as glycogen storage disease and galactosemia. Endocrine causes of hypoglycemia include adrenal insufficiency and hypopituitarism, the latter of which should be suspected in the setting of hypoglycemia and micropenis. Hypoglycemia also occurs in infants with birth asphyxia, hypoxia, and bacterial or viral sepsis.

Clinical Findings and Monitoring

The signs of hypoglycemia in the newborn infant may be nonspecific and subtle: lethargy, poor feeding, irritability, tremors, jitteriness, apnea, and seizures. Hypoglycemia due to increased insulin is the most severe and most resistant to treatment. Cardiac failure may occur in severe cases, particularly in IDMs with cardiomyopathy. Hypoglycemia in hyperinsulinemic states can develop within the first 30–60 minutes of life.

Blood glucose can be measured by heelstick using a bedside glucometer. All infants at risk should be screened, including IDMs, IUGR infants, premature infants, and any infant with suggestive symptoms. All low or borderline values should be confirmed by laboratory measurement of blood glucose concentration. It is important to continue surveillance of glucose concentration until the baby has been on full enteral feedings without intravenous supplementation for 24 hours, with a target of > 45 mg/dL before feeding. Relapse of hypoglycemia thereafter is unlikely.

Infants with hypoglycemia requiring IV glucose infusions for more than 5 days should be evaluated for less common disorders, including inborn errors of metabolism, hyperinsulinemic states, and deficiencies of counterregulatory hormones.

Treatment

Therapy is based on the provision of enteral or parenteral glucose. Treatment guidelines are shown in Table 2–12. In hyperinsulinemic states, glucose boluses should be avoided and a higher glucose infusion rate used. After initial correction with a bolus of 10% dextrose in water (D10W; 2 mL/kg), glucose infusion should be increased gradually as needed from a starting rate of 6 mg/kg/min. IDMs and IUGR infants with polycythemia are at greatest risk for symptomatic hypoglycemia.

Table 2–12. Hypoglycemia: suggested therapeutic regimens.

<table>
<thead>
<tr>
<th>Screening Test</th>
<th>Presence of Symptoms</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>30–40 mg/dl</td>
<td>No symptoms of hypoglycemia</td>
<td>Draw blood glucose; if the infant is alert and vigorous, feed; follow with frequent glucose monitoring. If the infant continues to have blood glucose &lt; 40 mg/dL or is unable to feed, provide intravenous glucose at 6 mg/kg/min (D10W at 3.6 mL/kg/h).</td>
</tr>
<tr>
<td>&lt; 40 mg/dL</td>
<td>Symptoms of hypoglycemia present</td>
<td>Draw blood glucose; provide bolus of D10W (2 mL/kg) followed by an infusion of 6 mg/kg/min (3.6 mL/kg/h).</td>
</tr>
<tr>
<td>&lt; 30 mg/dL</td>
<td>With or without symptoms of hypoglycemia</td>
<td>Draw blood glucose; provide bolus of D10W followed by an infusion of 6 mg/kg/min. If IV access cannot be obtained immediately, an umbilical vein line should be used.</td>
</tr>
</tbody>
</table>
Screening Test

<table>
<thead>
<tr>
<th>Presence of Symptoms</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rapid bedside determination.</td>
<td></td>
</tr>
<tr>
<td>Laboratory confirmation.</td>
<td></td>
</tr>
</tbody>
</table>

Prognosis

The prognosis of hypoglycemia is good if therapy is prompt. CNS sequelae are more common in infants with hypoglycemic seizures and in neonates with persistent hyperinsulinemic hypoglycemia. Hypoglycemia may also potentiate brain injury after perinatal depression or other insults, and should be avoided.


RESPIRATORY DISTRESS IN THE TERM NEWBORN INFANT

ESSENTIALS OF DIAGNOSIS & TYPICAL FEATURES

- Tachypnea, respiratory rate > 60 breaths/min.
- Intercostal and sternal retractions.
- Expiratory grunting.
- Cyanosis in room air.

General Considerations

Respiratory distress is one of the most common symptom complexes of the newborn. It may result from cardiopulmonary and noncardiopulmonary causes (Table 2–13). Chest radiography, arterial blood gases, and pulse oximetry are useful in assessing the cause and severity of the distress. It is important to consider the noncardiopulmonary causes (see Table 2–13), because the natural tendency is to focus on the heart and lungs. Most of the noncardiopulmonary causes can be ruled out by the history, physical examination, and a few simple laboratory tests. The most common pulmonary causes of respiratory distress in the full-term infant are transient tachypnea, aspiration syndromes, congenital pneumonia, and air leaks.

Table 2–13. Causes of respiratory distress in the newborn.

- Noncardiopulmonary
  - Hypothermia or hyperthermia
  - Hypoglycemia
  - Polycythemia
  - Metabolic acidosis
  - Drug intoxications or withdrawal
  - Insult to the central nervous system
    - Asphyxia
- Hemorrhage
  - Neuromuscular disease
  - Phrenic nerve injury
  - Skeletal dysplasia

• Cardiovascular
  - Left-sided outflow tract obstruction
    - Hypoplastic left heart
    - Aortic stenosis
    - Coarctation of the aorta, interrupted aortic arch
  - Cyanotic lesions
    - Transposition of the great vessels
    - Total anomalous pulmonary venous return
    - Tricuspid atresia
    - Right-sided outflow obstruction

• Respiratory Tract
  - Upper airway obstruction
    - Choanal atresia
    - Vocal cord paralysis
    - Subglottic stenosis
    - Lingual thyroid
  - Meconium aspiration
  - Clear fluid aspiration
  - Transient tachypnea
  - Pneumonia
  - Pulmonary hypoplasia
  - Hyaline membrane disease
  - Pneumothorax
  - Pleural effusions
  - Mass lesions
    - Lobar emphysema
    - Cystic adenomatoid malformation
- Congenital diaphragmatic hernia


A. Transient Tachypnea (Retained Fetal Lung Fluid)

Respiratory distress is typically present at birth, usually associated with a mild-to-moderate oxygen requirement (25%–50% O₂). The infant is usually full term or late preterm, nonasphyxiated, and born following a short labor or cesarean section without labor. The pathogenesis of the disorder is related to delayed clearance of fetal lung fluid via the circulation and pulmonary lymphatics. The chest radiograph shows perihilar streaking and fluid in interlobar fissures. Resolution usually occurs within 12–24 hours. Nasal CPAP can be very helpful in the clearance of the fluid.

B. Aspiration Syndromes

Aspiration syndromes typically occur in full term or late preterm infants with fetal distress prior to delivery or depression at delivery. Blood or meconium is often present in the amniotic fluid. Aspiration of meconium most commonly occurs in utero as a stressed infant gasps. Delivery room management of these infants is discussed in the resuscitation section. Respiratory distress is present from birth, often accompanied by a barrel chest appearance and coarse breath sounds. Pneumonitis may cause an increasing O₂ need and may require intubation and ventilation. The chest radiograph shows coarse irregular infiltrates, hyperexpansion, and in the worst cases, lobar consolidation. In some cases, because of secondary surfactant deficiency, the radiograph shows a diffuse homogeneous infiltrate pattern. Infants who aspirate are at risk of pneumothorax because of uneven aeration with segmental overdistention and are at risk for persistent pulmonary hypertension (see section on Cardiac Problems in the Newborn Infant, later).

C. Congenital Pneumonia

The lungs are the most common site of infection in the neonate. Infections usually ascend from the genital tract before or during labor, with the vaginal or rectal flora the most likely agents (group B streptococci and Escherichia coli). Infants of any gestational age, with or without a history of prolonged rupture of membranes, chorioamnionitis, or maternal antibiotic administration, may be affected. Respiratory distress may begin at birth or may be delayed for several hours. The chest radiograph may resemble that of retained lung fluid or hyaline membrane disease. Rarely, there may be a lobar infiltrate or pleural effusion. Shock, poor perfusion, absolute neutropenia (< 2000/mL), and elevated C-reactive protein provide supportive evidence for pneumonia. Gram stain of tracheal aspirate may be helpful. Because no signs or laboratory findings can confirm a diagnosis of pneumonia, all infants with respiratory distress should have a blood culture performed and should receive broad-spectrum antibiotic therapy (ampicillin, 100 mg/kg in two divided doses, and gentamicin, 4 mg/kg q24h or 2.5 mg/kg q12h) until the diagnosis of bacterial infection is eliminated.

D. Spontaneous Pneumothorax

Spontaneous pneumothorax occurs in 1% of all deliveries. Risk is increased by manipulations such as positive-pressure ventilation (PPV). Respiratory distress (primarily tachypnea) is present from birth and typically is not severe. Breath sounds may be decreased on the affected side; heart tones may be shifted toward the opposite side and may be distant. The chest radiograph shows pneumothorax or pneumomediastinum.

Treatment usually consists of supplemental O₂ and watchful waiting. Breathing 100% O₂ for a few hours may accelerate reabsorption of extrapulmonary gas by creating a diffusion gradient for nitrogen across the surface of the lung (nitrogen washout technique). This is effective only if the infant was breathing room air or a low O₂ concentration at the time of the pneumothorax; the long-term effects of the use of 100% O₂ in this way are unknown. Drainage by needle thoracentesis or tube thoracostomy is occasionally required. There is a slightly increased risk of renal abnormalities associated with spontaneous pneumothorax. Thus, careful physical examination of the kidneys and observation of urine output are indicated. If pulmonary hypoplasia with pneumothorax is suspected, renal ultrasound is also indicated.

E. Other Respiratory Tract Causes

Other respiratory tract causes of respiratory distress are rare. Bilateral choanal atresia should be suspected if there is no air movement when the infant breathes through the nose. These infants have good color and heart rate while crying at delivery
but become cyanotic and bradycardiac when they resume normal nasal breathing. Other causes of upper airway obstruction usually produce some degree of stridor or poor air movement despite good respiratory effort. Pleural effusion is likely in hydropic infants. Space-occupying lesions cause a shift of the mediastinum with asymmetrical breath sounds and are apparent on chest radiographs. Many are associated with severe respiratory distress.

**Treatment**

Whatever the cause, neonatal respiratory distress is treated with supplemental oxygen sufficient to maintain a Pao\(_2\) of 60–70 mm Hg and an oxygen saturation by pulse oximetry (Spo\(_2\)) of 92%–96%. Oxygen should be warmed, humidified, and delivered through an air blender. Concentration should be measured with a calibrated oxygen analyzer. An umbilical or peripheral arterial line should be inserted in infants requiring more than 45% fraction of inspired oxygen (FiO\(_2\)) by 4–6 hours of life to allow frequent blood gas determinations. Noninvasive monitoring with pulse oximetry should be used.

Other supportive treatment includes IV glucose and water. Unless infection can be ruled out, blood cultures should be obtained and broad-spectrum antibiotics started. Volume expansion (normal saline) can be given in infusions of 10 mL/kg over 30 minutes for low blood pressure, poor perfusion, and metabolic acidosis. Other specific testing should be done as indicated by the history and physical examination. In most cases, a chest radiograph, blood gas measurements, CBC, and blood glucose determination allow a diagnosis.

Intubation and ventilation should be undertaken if there is respiratory failure (Pao\(_2\) < 60 mm Hg in > 60% FiO\(_2\), Paco\(_2\) > 60 mm Hg, or recurrent apnea). Peak pressures should be adequate to produce chest wall expansion and audible breath sounds (usually 18–24 cm H\(_2\)O). Positive end-expiratory pressure (4–6 cm H\(_2\)O) should be used. Ventilation rates of 20–40 breaths/min are usually required. The goal is to maintain a Pao\(_2\) of 60–70 mm Hg and a Paco\(_2\) of 45–55 mm Hg.

**Prognosis**

Most respiratory conditions of the full-term infant are acute and resolve in the first several days. Meconium aspiration and congenital pneumonia carry a mortality rate of up to 10% and can produce significant long-term pulmonary morbidity. Mortality has been reduced by use of high-frequency oscillatory ventilation and inhaled nitric oxide for treatment of pulmonary hypertension. Only rarely is extracorporeal membrane oxygenation (ECMO) needed as rescue therapy.


**HEART MURMURS**

Heart murmurs are common in the first days of life and do not usually signify structural heart problems. If a murmur is present at birth, it should be considered a valvular problem until proved otherwise because the common benign transitional murmurs (eg, patent ductus arteriosus) are not audible until hours after birth. Loud (grade 3+/6), harsh, or diastolic murmurs are more likely to be pathologic.

If an infant is pink, well-perfused, and in no respiratory distress, with palpable and symmetrical pulses (right brachial pulse no stronger than the femoral pulse), the murmur is most likely transitional. Transitional murmurs are soft (grade 1-2/6), heard at the left upper to midsternal border, and generally loudest during the first 24 hours. If the murmur persists beyond 24 hours of age, blood pressure in the right arm and a leg should be determined. If there is a difference of more than 15 mm Hg (arm > leg) or if the pulses in the lower extremities are difficult to palpate, a cardiologist should evaluate the infant for coarctation of the aorta. If there is no difference, the infant can be discharged home with follow-up in 2–3 days for auscultation and evaluation for signs of congestive failure. If signs of congestive failure or cyanosis are present, the infant should be referred for evaluation without delay. If the murmur persists without these signs, the infant can be referred for elective evaluation at age 2–4 weeks. Many centers now perform routine pulse oximetry screening in the nursery to identify
infants with serious congenital heart disease. Oxygen saturation less than 95% at sea level is evaluated by clinical assessment and echocardiogram.

Mahle WT et al., on behalf of the American Heart Association Congenital Heart Defects Committee of the Council on Cardiovascular Disease in the Young, Council on Cardiovascular Nursing, and Interdisciplinary Council on Quality of Care and Outcomes Research, and the American Academy of Pediatrics Section on Cardiology and Cardiac Surgery, and Committee on Fetus and Newborn: Role of pulse oximetry in examining newborns for congenital heart disease: a scientific statement from the AHA and AAP. Pediatrics 2009;124:823 [PubMed: 19581259].

BIRTH TRAUMA

Most birth trauma is associated with difficult delivery (e.g., large fetus, abnormal presenting position, or fetal distress requiring rapid extraction). The most common injuries are soft tissue bruising, fractures (clavicle, humerus, or femur), and cervical plexus palsies. Skull fracture, intracranial hemorrhage (primarily subdural and subarachnoid), and cervical spinal cord injury can also occur.

Fractures are often diagnosed by the obstetrician, who may feel or hear a snap during delivery. Clavicular fractures may cause decreased spontaneous movement of the arm, with local tenderness and crepitus. Humeral or femoral fractures usually cause tenderness and swelling over the shaft with a diaphyseal fracture, and always cause limitation of movement. Epiphyseal fractures are harder to diagnose radiographically owing to the cartilaginous nature of the epiphysis. After 8–10 days, callus is visible on radiographs. Treatment consists of gentle handling, with immobilization for 8–10 days: the humerus against the chest with elbow flexed; the femur with a posterior splint from below the knee to the buttock.

Brachial plexus injuries may result from traction as the head is pulled away from the shoulder during delivery. Injury to the C5–C6 roots is most common (Erb-Duchenne palsy). The arm is limp, adducted, and internally rotated, extended and pronated at the elbow, and flexed at the wrist (so-called waiter's tip posture). Grasp is present. If the lower nerve roots (C8–T1) are injured (Klumpke palsy), the hand is flaccid. If the entire plexus is injured, the arm and hand are flaccid, with associated sensory deficit. Early treatment for brachial plexus injury is conservative, because function usually returns over several weeks. Referral should be made to a physical therapist so that parents can be instructed on range-of-motion exercises, splinting, and further evaluation if needed. Return of function begins in the deltoid and biceps, with recovery by 3 months in most cases.

Spinal cord injury can occur at birth, especially in difficult breech extractions with hyperextension of the neck, or in midforceps rotations when the body fails to turn with the head. Infants are flaccid, quadriplegic, and without respiratory effort at birth. Facial movements are preserved. The long-term outlook for such infants is poor.

Facial nerve palsy is sometimes associated with forceps use but more often results from in-utero pressure of the baby's head against the mother's sacrum. The infant has asymmetrical mouth movements and eye closure with poor facial movement on the affected side. Most cases resolve spontaneously in a few days to weeks.

Subgaleal hemorrhage into the large potential space under the scalp (Figure 2–5) is associated with difficult vaginal deliveries and repeated attempts at vacuum extraction. It can lead to hypovolemic shock and death from blood loss and coagulopathy triggered by consumption of clotting factors. This is an emergency requiring rapid replacement of blood and clotting factors.

Figure 2–5.

INFANTS OF MOTHERS WHO ABUSE DRUGS

Studies demonstrate that 11% of pregnant women use alcohol, 5% use illicit drugs, and 16% use tobacco. Use of illegal drugs, including marijuana, opiates, cocaine, and methamphetamine, is highest in 15–17 year olds (16%). Because mothers may abuse many drugs and give an unreliable history of drug usage, it is difficult to pinpoint which drug is causing the morbidity seen in a newborn infant. Early hospital discharge makes recognition of these infants based on physical findings and abnormal behavior difficult. Except for alcohol, a birth defect syndrome has not been clearly defined for any other substance of abuse.

1. Cocaine & Methamphetamine

ESSENTIALS OF DIAGNOSIS & TYPICAL FEATURES

- Triad of no prenatal care, premature delivery, placental abruption.
- Possible IUGR.
- Irritability.

Cocaine and methamphetamine are currently the most common hard drugs used during pregnancy, often in association with other drugs such as tobacco, alcohol, and marijuana. These stimulants can cause maternal hypertension, decreased uterine blood flow, fetal hypoxemia, uterine contractions, and placental abruption. Rates of stillbirth, placental abruption, symmetric IUGR, and preterm delivery are increased two- to fourfold in users. In the high-risk setting of no prenatal care, placental abruption, and preterm labor, urine toxicology screens should be performed on the mother and infant; consent from the mother for testing her urine may be required. Meconium should be sent for drug screening as it enhances diagnosis by indicating cumulative drug exposure from the first trimester forward. Although no specific malformation complex or withdrawal syndrome is described for cocaine and methamphetamine abuse, infants may show irritability and growth restriction.

Children of mothers who use methamphetamines are at particularly high risk for neglect and abuse. Social services evaluation is especially important to assess the home environment for these risks. The risk of SIDS is three to seven times higher in infants of users than in those of nonusers (0.5%–1% of exposed infants). The risk may be lessened by environmental interventions such as avoidance of tobacco smoke and supine infant positioning. Long-term neurobehavioral effects have been described.

2. Opioids

ESSENTIALS OF DIAGNOSIS & TYPICAL FEATURES

- CNS—irritability, hyperactivity, hypertonicity, incessant high-pitched cry, tremors, seizures.
- GI—vomiting, diarrhea, weight loss, poor feeding, incessant hunger, excessive salivation.
• Metabolic and respiratory—nasal stuffiness, sneezing, yawning, sweating, hyperthermia.

• Often IUGR.

Clinical Findings

The withdrawal signs seen in infants born to narcotic-addicted mothers, whether heroin, prescription narcotics, or methadone, are similar. The symptoms in infants born to methadone-maintained mothers may be delayed in onset, more severe, and more prolonged than those seen with heroin addiction. Symptoms usually begin within 1–3 days of life. The clinical picture is typical enough to suggest a diagnosis even if a maternal history of narcotic abuse has not been obtained. Confirmation should be made with urine and meconium toxicology screening.

Treatment

If opioid abuse or withdrawal is suspected, the infant is not a candidate for early discharge. A serial scoring system should be used. Supportive treatment includes swaddling the infant and providing a quiet, dimly lit environment, minimizing procedures, and disturbing the infant as little as possible. Specific treatment should be used when the infant has severe symptoms or excessive weight loss. No single drug has been identified as optimally effective. Phenobarbital 16 mg/kg orally as a loading dose and 2.5 mg/kg orally twice a day may be used for irritability. If diarrhea and weight loss are prominent, or if adequate control of symptoms has not been achieved, oral morphine sulphate 0.1–0.5 mg/kg/dose q6–12h, titrated to improve symptoms, or methadone (0.05–0.1 mg/kg q6h) are more beneficial than phenobarbital alone. It can be very difficult to wean some of these infants off of methadone. It is also important to review maternal tests for HIV, hepatitis B, and hepatitis C, as all are common in intravenous drug users.

Prognosis

These infants often have chronic neurobehavioral handicaps; however, it is difficult to distinguish the effects of in-utero drug exposure from those of the environment. Infants of opioid abusers have a four- to fivefold increased risk of SIDS.

3. Alcohol

Alcohol is the only recreational drug of abuse that is clearly teratogenic, and prenatal exposure to alcohol is the most common preventable cause of mental retardation. Prevalence estimates of fetal alcohol syndrome (FAS) in the United States range from 0.5 to 2 per 1000 live births with up to 1 in 100 having lesser effects (fetal alcohol spectrum disorders). The effects of alcohol on the fetus and newborn are determined by the degree and timing of ethanol exposure and by the maternal, fetal, and placental metabolism of ethanol, which is likely genetically determined. Although there is no clear evidence that minimal amounts of alcohol are harmful, there is no established safe dose. Fetal growth and development are adversely affected if drinking continues throughout the pregnancy, and infants can occasionally experience withdrawal similar to that associated with maternal opioid abuse. Clinical features of FAS that may be observed in the newborn period are listed in Table 2–14. This diagnosis is usually easier to recognize in older infants and children. Long-term neurobehavioral consequences are well described with in utero alcohol exposure.

Table 2–14. Features observed in fetal alcohol syndrome in the newborn.

• Craniofacial
  ○ Short palpebral fissures
  ○ Thin vermilion of upper lip
  ○ Flattened philtrum

• Growth
  ○ Prenatal and postnatal growth deficiency (small for gestational age, failure to thrive)

• Central nervous system
  ○ Microcephaly
  ○ Partial or complete agenesis of the corpus callosum
OPTIC NERVE HYPOLASIA

HYPOTONIA, POOR FEEDING

4. Tobacco Smoking

Smoking has a negative effect on fetal growth rate. The more the mother smokes, the greater is the degree of IUGR. There is a twofold increase in low birth weight even in light smokers (< 10 cigarettes per day). Smoking during pregnancy has been associated with mild neurodevelopmental handicaps. The possibility of multiple drug abuse also applies to smokers, and the potential interaction of multiple factors on fetal growth and development must be considered.

5. Toluene Embryopathy

Solvent toxicity may be intentional (paint, lacquer, or glue sniffing) or environmental (dry cleaning industry). The active organic solvent in these agents is toluene. Features attributable to in-utero toluene exposure are prematurity, IUGR, microcephaly, craniofacial abnormalities similar to those associated with in-utero alcohol exposure (see Table 2–14), large anterior fontanelle, hair patterning abnormalities, nail hypoplasia, and renal anomalies. Long-term effects include postnatal growth deficiency and developmental delay.

6. Marijuana

Marijuana is the most frequently used illegal drug. It does not appear to be teratogenic, and although a mild abstinence-type syndrome has been described, infants exposed to marijuana in utero rarely require treatment. Some long-term neurodevelopmental problems, particularly disordered sleep patterns, have been noted.

7. Other Drugs

Other drugs with potential effects on the newborn fall in two categories. First are drugs to which the fetus is exposed because of therapy for maternal conditions. The human placenta is relatively permeable, particularly to lipophilic solutes. If possible, maternal drug therapy should be postponed until after the first trimester to avoid teratogenic effects. Drugs with potential fetal toxicity include antineoplastics, antithyroid agents, warfarin, lithium, and angiotensin-converting enzyme inhibitors (eg, captopril and enalapril). Anticonvulsants, especially high-dose or multiple drug therapy, may be associated with craniofacial abnormalities. The use of selective serotonin reuptake inhibitors (SSRIs), benzodiazepines, and antipsychotic medications appears to be generally safe, and risk should be balanced against the risk of untreated psychiatric conditions in the mother. However, up to 33% of infants exposed to SSRI medications in utero experience signs of neonatal abstinence syndrome during the first days of life. Paroxetine seems to have the greatest propensity to cause abstinence symptoms. Phenobarbital may be used for severe irritability. SSRI use in pregnancy has also been associated with persistent pulmonary hypertension of the newborn.

In the second category are drugs transmitted to the infant in breast milk. Most drugs taken by the mother achieve some concentration in breast milk, although they usually do not present a problem to the infant. If the drug is one that could have adverse effects on the infant, timing breast feeding to coincide with trough concentrations in the mother may be useful.

MULTIPLE BIRTHS

ESSENTIALS OF DIAGNOSIS & TYPICAL FEATURES

- Monochorial twins
  - Always monozygous (identical twins) and same sex.
  - Can be diamniotic or monoamniotic.
  - Risk for twin-to-twin transfusion and higher risk of congenital anomalies, neurodevelopmental problems, and cerebral palsy.

- Dichorial twins
  - Either dizygous (fraternal twins) or monozygous (identical twins); same sex or different sex.
  - Can have growth restriction due to abnormal placental implantation.
  - Not at risk for twin transfusion syndrome; less risk for anomalies and neurodevelopmental problems than monochorial twins.

Historically, twinning occurred at a rate of 1 in 80 pregnancies (1.25%). The incidence of twinning and higher-order multiple births in the United States has increased because of assisted reproductive technologies. In 2005, twins occurred in 3.2% of live births in the United States, a 70% increase since 1980.

A distinction should be made between dizygous (fraternal) and monozygous (identical) twins. Race, maternal parity, and maternal age affect the incidence of dizygous, but not monozygous, twinning. Drugs used to induce ovulation, such as clomiphene citrate and gonadotropins, increase the incidence of dizygotic or polyzygotic twinning. Monozygous twinning also seems to be more common after assisted reproduction. The incidence of malformations is also increased in identical twins and may affect only one of the twins. If a defect is found in one twin, the other should be examined carefully for lesser degrees of the same defect.

Early transvaginal ultrasound and examination of the placenta after birth can help establish the type of twinning. Two amniotic membranes and two chorionic membranes are found in all dizygous twins and in one-third of monozygous twins even when the placental disks appear to be fused into one. A single chorionic membrane always indicates monozygous twins. The rare monochorial, monoamniotic situation (1% of twins) is especially dangerous, with a high risk of antenatal cord entanglement and death of one or both twins. Close fetal surveillance is indicated, and preterm delivery is often elected.

Complications of Multiple Births

A. Intrauterine Growth Restriction

There is some degree of IUGR in most multiple pregnancies, especially after 32 weeks, although it is usually not clinically significant with two exceptions. First, in monochorial twin pregnancy an arteriovenous shunt may develop between the twins (twin-twin transfusion syndrome). The twin on the venous side (recipient) becomes plethoric and larger than the smaller anemic twin (donor), who may ultimately die or be severely growth restricted. The occurrence of polyhydramnios in the larger twin and severe oligohydramnios in the smaller may be the first sign of this problem. Second, discordance in size (birth weights that are significantly different) can also occur when separate placentas are present if one placenta develops poorly, because of a poor implantation site. In this instance, no fetal exchange of blood takes place but the growth rates of the two infants are different.

B. Preterm Delivery
Length of gestation tends to be inversely related to the number of fetuses. The mean age at delivery for singletons is 38.8 weeks, for twins 35.3 weeks, for triplets 32.2 weeks, and for quadruplets 29.9 weeks. The prematurity rate in multiple gestations is 5–10 times that of singletons, with 50% of twins and 90% of triplets born before 37 weeks. There is an increased incidence of cerebral palsy in multiple births, more so with monochorial than dichorial infants. Prematurity is the main cause of increased mortality and morbidity in twins, although in the case of monochorial twins, intravascular exchange through placental anastomoses, particularly after the death of one twin, also increases the risk substantially.

C. Obstetric Complications

Polyhydramnios, pregnancy-induced hypertension, premature rupture of membranes, abnormal fetal presentations, and prolapsed umbilical cord occur more frequently in women with multiple fetuses. Multiple pregnancy should always be identified prenatally with ultrasound examinations; doing so allows the obstetrician and pediatrician or neonatologist to plan management jointly. Because neonatal complications are usually related to prematurity, prolongation of pregnancy significantly reduces neonatal morbidity.


NEONATAL INTENSIVE CARE

PERINATAL RESUSCITATION

Perinatal resuscitation refers to the steps taken by the obstetrician to support the infant during labor and delivery and the resuscitative steps taken by the pediatrician after delivery. Intrapartum support includes maintaining maternal blood pressure, maternal oxygen therapy, positioning the mother to improve placental perfusion, readjusting oxytocin infusions or administering a tocolytic if appropriate, amnioinfusion, minimizing trauma to the infant, obtaining all necessary cord blood samples, and completing an examination of the placenta. The pediatrician or neonatologist focuses on temperature support, initiation and maintenance of effective ventilation, maintenance of perfusion and hydration, and glucose regulation.

A number of conditions associated with pregnancy, labor, and delivery place the infant at risk for birth asphyxia: (1) maternal diseases such as diabetes, pregnancy-induced hypertension, heart and renal disease, and collagen-vascular disease; (2) fetal conditions such as prematurity, multiple births, growth restriction, and fetal anomalies; and (3) labor and delivery conditions, including fetal distress with or without meconium in the amniotic fluid, and administration of anesthetics and opioid analgesics.

Physiology of Birth Asphyxia

Birth asphyxia can be the result of (1) acute interruption of umbilical blood flow (eg, prolapsed cord with cord compression), (2) premature placental separation, (3) maternal hypotension or hypoxia, (4) chronic placental insufficiency, and (5) failure to perform resuscitation properly.

The neonatal response to asphyxia follows a predictable pattern (Figure 2–6). The initial response to hypoxia is an increase in respiratory rate and a rise in heart rate and blood pressure. Respirations then cease (primary apnea) as heart rate and blood pressure begin to fall. The initial period of apnea lasts 30–60 seconds. Gasping respirations (3–6 per minute) then begin, while heart rate and blood pressure gradually decline. Secondary or terminal apnea then ensues, with further decline in heart rate and blood pressure. The longer the duration of secondary apnea, the greater is the risk for organ injury. A cardinal feature of the defense against hypoxia is the underperfusion of certain tissue beds (eg, skin, muscle, kidneys, and GI tract), which allows maintenance of perfusion to core organs (ie, heart, brain, and adrenals).

Figure 2–6.