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PART I

NEONATAL AND INFANT CARE IN THE EMERGENCY DEPARTMENT – THE BASIC PRINCIPLES

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1 Approach to the Newborn Examination

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INTRODUCTION

Newborns can be some of the most challenging patients evaluated in the emergency department (ED). It is important that health care providers understand the anatomical and physiological differences present in healthy newborns and very young infants. In addition, approximately one in five healthy newborns will have at least one congenital anomaly. As the number of congenital anomalies in an infant increases, the risk of major anomalies being present also increases.[1] A thorough, systematic approach to evaluating the newborn will help ensure that these anomalies, if present, are detected and that significant findings are not overlooked. It is important to recognize normal anomalies in order to prevent costly workups. It is also crucial for the practitioner not to miss an abnormal finding because he or she thinks that it is normal. Illness presentation in neonates can be subtle in that a direct history is not possible and the physical examination is often unreliable. The clinician must rely on vague symptoms, such as fussiness or eating less, and a comprehensive physical examination to detect illness.

A complete physical examination can be time-consuming. When time is limited, it is still important to have a concise yet thorough method for completing the examination. In the rapid examination, emphasis needs to be placed on the overall wellness of the infant, the heart, the lungs and the abdomen and any area identified as a potential problem area. A complete neurological examination is quite involved and may not be possible in the time available. The infant is observed for any signs of distress, including inconsolability and respiratory distress. The sleeping infant should be calm. While awake, the infant should be vigorous and interactive. Testing a few of the primitive reflexes generally can give a good sense of the baby's neurological condition. Monitor for symmetric facies and spontaneous limb movement. Any deficits need to be fully evaluated.

VITAL SIGNS

The general assessment also needs to include evaluation of the infant's vital signs. It is crucial to remember that the "normal" vital signs of an infant vary greatly depending on age. For example, a respiratory rate of 60 breaths per minute would be normal for a newborn but not for a 9 month old. Being unfamiliar with "normal" ranges for vital signs can lead to false views of the infant's overall well-being (Table 1.1. Vital signs also need to be correlated with other clinical indicators to better determine if the values are of concern (e.g., a heart rate of 150 beats per minute with poor perfusion is more concerning than a heart rate of 150 beats per minute with no signs of shock).

In neonates, fevers carry an increased association with serious bacterial infections, including osteomyelitis, sepsis, meningitis and urinary tract infections. The latter three are difficult to evaluate for during a physical examination. It is for this reason that infants younger than 28 days with a fever of 38°C (100.4°F) or higher are admitted to the hospital for a "rule out sepsis" evaluation. One should be aware that bundling an infant has often been attributed as the cause of a fever; however, it has been shown that bundling does not raise the core temperature and therefore should never be used as an excuse to avoid further evaluation.[2] One should also be alert for hypothermia in this age group as this can be an indicator of serious infection or other pathology. Hypothermia, fevers and temperature swings may be signals of not only infection but also of other problems such as hypoglycemia or hypo/hyperthyroidism.

The weight of a newborn infant should be considered another important vital sign. The body length and head

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Table 1.1. Normal vital signs in the infant

Age	Heart rate*	Respiratory rate†	Systolic blood pressure
Newborn	90–180	40–60	60–90 mm Hg
1 mo	110–180	30–50	70–104 mm Hg
3 mo	110–180	30–45	70–104 mm Hg
6 mo	110–180	20–35	72–110 mm Hg

*Measured in beats per minute.
†Measured in breaths per minute.
Normal ranges for specified vital signs are listed. Ranges were obtained from *The Pediatric Emergency Medicine Resource*, revised 4th ed., 2006, Jones and Bartlett, p. 108.

circumference also may be crucial to consider, depending upon the chief complaint. These measurements, especially appropriate weight gain, can be early clues to potential problems or developing pathology. The average weight of a full-term newborn is 3.4 kg (7.5 lb). Parents often can recite the exact weight of their newborn at the time of the delivery. Newborns lose, on average, approximately 10% of their birth weight during the first few days after birth. This weight generally should be gained back by the end of the first 7 to 10 days. Average subsequent weight gain in the newborn period is 15 to 30 g (0.5–1 oz) per day. Standardized growth charts are available that can be used to determine appropriate weight for gestational age in premature infants. These growth charts are available for download from http://www.cdc.gov/growthcharts. Knowing the gestational age is important because a difference of 1 to 2 weeks can significantly change the average weight for a premature infant. By definition, an infant is the appropriate weight for gestational age if the weight is within 2 standard deviations (SD) of the mean. Several evaluation tools exist to help determine gestational age if it is unknown. These tools rely on the physical examination of the infant including neuromuscular development, skin findings such as creases, ear laxity, and breast/genital development.[3] When evaluating growth of infants, one should remember to correct the plotting on growth charts for gestational age. (e.g., a 6 month old who was born 32 weeks premature would be plotted on the 4-month-old line to account for the 8 weeks of prematurity.) This correction is continued until the infant reaches 2 years of age.

Babies who are large for gestational age (LGA) may have an underlying syndrome or may be large simply due to familial inheritance. If familial reasons are suspected, one can plot the parents' weight on growth charts to determine their percentiles. Parents in upper percentiles tend to have babies who are also in upper percentiles. Most commonly, LGA babies are born to diabetic mothers. (Infants of diabetic mothers have a variety of potential complications, including hypoglycemia, cardiac septal hypertrophy and meconium plug.)[4] Infants are particularly at risk for being LGA if the mother's blood sugar was poorly controlled during the last trimester.

Numerous syndromes can lead to LGA babies, including Soto, Beckwith-Wiedemann and Simpson-Golabi-Behmel syndrome. If a genetic syndrome is suspected, it is recommended that genetics consultation be obtained for further evaluation.

Similarly, small for gestational age (SGA) babies are at risk for congenital anomalies and complications; 20% of infants with serious congenital anomalies are SGA.[3] SGA infants should be monitored closely for development of hypoglycemia and temperature instability.

Both macrocephaly and microcephaly are associated with pathological findings. As an isolated finding, macrocephaly may be inherited from a parent. It shows an autosomal dominant inheritance pattern. Parental head circumference can be plotted to determine the percentiles using standard growth charts and plotting at the 18-year-old point.

Although macrocephaly may be inherited, most commonly it is associated with hydrocephalus.[5] Other physical findings that increase the suspicion of hydrocephalus include widening sutures or a bulging fontanel. A head circumference that is rapidly enlarging is very suspicious for hydrocephalus. Repeated examinations of the infant's skull over time allow for these changes to be noticed.

Microcephaly is more likely to be pathological and should be fully evaluated. Due to the open fontanel, a cranial ultrasound can provide significant information about underlying structures and spares the infant radiation that would be needed for a CT scan.

EVALUATION OF THE HEAD

The newborn skull is composed of a total of 22 bones: 8 encompass the brain and 14 form the facial skull. Most of these bones are not fused together at birth. This allows for significant molding to occur during the birth process. Resolution of molding typically occurs over the course of 3 to 5 days. This resolution can cause the head circumference

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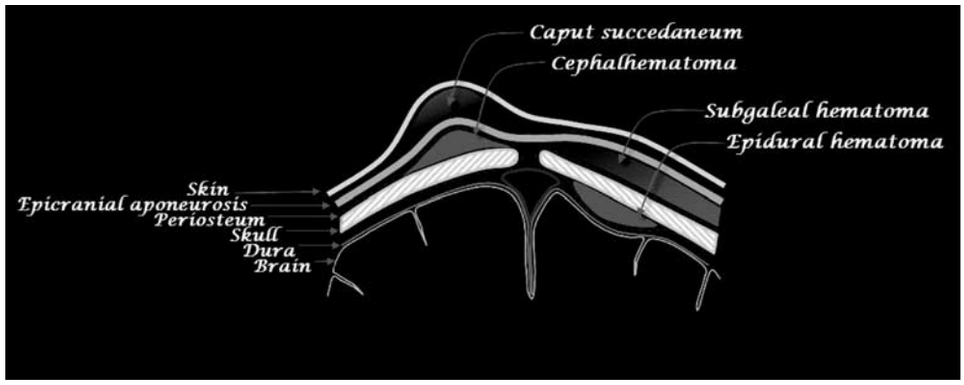

Figure 1.1. Caput succedaneum is the most common scalp injury due to birth trauma. Created by AMH Sheikh, Jan. 25, 2006. Used with permission.

to increase by as much as 1 cm and should not be mistaken for underlying hydrocephalus.[3]

Several other findings related to the birth process can present in the head as well. Caput succedaneum very commonly is seen; it is the most common scalp injury caused by birth trauma.[6] Caput succedaneum develops as a result of localized soft tissue edema. Vacuum extraction is particularly well known to cause it. The edema typically resolves within 48 hours (Figure 1.1). Caput succedaneum may cross suture lines, unlike a cephalhematoma. Cephalhematomas are blood collections that occur in the subperiosteal space. They occur in 1.5% to 2.5% of all deliveries. Vacuum and forceps extractions increase the incidence of a cephalhematoma to 9.8% to 14.8% and 4.1%, respectively.[6,7] Resolution of this bleed may take several days to weeks. Such a bleed also increases the risk of developing significant hyperbilirubinemia as the red blood cells break down.

Other important findings of the head examination include subgaleal bleeds, craniosynostosis and plagiocephaly, most commonly due to the infant repeatedly lying on the same side, with repeated pressure on one side of the head. One also should evaluate the fontanelles for their appropriate size and feel. A bulging fontanel is an indication of increased intracranial pressure. An overly large anterior fontanel may be associated with hypothyroidism. The anterior fontanel typically is closed by age 18 months. The posterior fontanel generally is closed within the first few months of life.[8]

The subgaleal space is a potential space that lies between the galeal aponeurosis and the periosteum. It can expand to allow significant amounts of blood into it. If this happens, the infant may require intensive resuscitation. Mortality from a subgaleal bleed can reach 22%.[9] The skull will often take on a diffusely boggy feel when a subgaleal bleed is present.

In addition to evaluating for bleeds, the suture lines should be examined for pathology. Skull growth is driven by underlying brain growth. Infants have approximately 40% of their ultimate skull volume at birth. Brain growth rapidly occurs such that by age 3 years it has reached 80% of adult size.[10] Normally, the suture lines allow the skull bones to expand as the brain becomes larger. However, in cases of craniosynostosis (premature fusion of a suture line), skull growth is limited along the fused suture. As a result, skull growth continues perpendicular to that suture line causing significant plagiocephaly.

Craniosynostosis occurs with an incidence of 1 in 1700 to 2500 births with nonsyndromic cases and 1 in 25,000 births with syndromic cases.[11] Cases may involve a single suture line, termed *simple craniosynostosis,* or may be compounded, involving two or more sutures. The sagittal suture is most commonly involved, followed by the coronal, metopic and lambdoid sutures in decreasing incidence order.

Although it is the most uncommon, occurring in approximately 3 in 100,000 births, lambdoid suture synostosis can be confused with positional plagiocephaly.[10,11] Physical examination readily distinguishes between the two by evaluating ear position from above. In positional plagiocephaly, the skull is moved forward, causing the ear to be shifted forward on the affected side. In lambdoid synostosis, skull bone growth is restricted, causing the ear to remain posterior compared to the opposite side.

Craniosynostosis may be inherited, most commonly via an autosomal dominant pattern with varying degrees

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of penetrance and expressivity. Fibroblast growth factor receptor (FGFR) mutations have been implicated in several syndromes associated with craniosynostosis. As an example, three well-known syndromes, including craniosynostoses, Crouzon's disease and Apert's syndrome, are associated with mutations in the FGFR2 gene.[12]

Fontanel size can be easily evaluated in an infant by simple palpation of the skull. If molding is present, the fontanel may be somewhat obscured by overlapping skull bones; however, as molding resolves, the fontanel should take on its appropriate size. The fontanel size is determined by its surrounding bony structures, thus anything affecting fontanel growth will, in turn, affect its size. For example, skull bone growth is delayed in patients with congenital hypothyroidism, leading to an increased fontanel size. Fontanel size is determined as a measure of its greatest width and its greatest length. On day 1 of life, the average size of a full-term infant's anterior fontanel is 0.6 cm to 3.6 cm (0.2 – 1.4 inches).[13] Large fontanelles are also associated with Down syndrome, achondroplasia and increased intracranial pressure (due to the spreading of the skull bones).

EVALUATION OF THE EYES

The red reflexes of the eyes are easily evaluated using a direct ophthalmoscope. Eyes should be assessed for the presence of a red reflex as well as for any differences between the two eyes. *Leukocoria,* or a white reflex, may be present due to congenital cataracts (which may also present as black spots in the red reflex), retinal detachment, vitreous opacities or, the more commonly thought of, retinoblastoma. Findings of leukocoria warrant evaluation by an ophthalmologist to determine its cause. One should also remember that darker skinned babies often do not have a classic red reflex. Instead, the reflex is often more orange or lighter colored. The red reflex should not, however, be white. A *coloboma,* a hole or defect in one of the structures of the eye, such as eyelid, iris, lens, retina or optic disc, also can be searched for during the evaluation of the red reflex. Additionally, the papillary reflexes and strabismus can be seen during this evaluation.

Retinoblastoma has been shown to be associated with mutations or deletions of the q14 band of chromosome 13.[14] It is important to evaluate for as it presents with an incidence of 1 in 17,000 infants. Approximately 30% of cases will be bilateral.[15]

Congenital cataracts may present as black or white spots in the red reflex. They are present from birth but may not present until later in life. They occur in 0.44% of live births and may increase in size as the child ages; 23% of congenital cataracts are inherited (most often in an autosomal dominant pattern). When bilateral involvement occurs, there is an increased risk of an underlying metabolic or systemic disease including galactosemia, congenital infections (rubella, cytomegalovirus, herpes simplex virus and toxoplasma, in particular), Down syndrome and other trisomy syndromes and prematurity.[16]

A disconjugate gaze may be noticed during examination of the red reflexes. One can use the papillary light reflex to assess easily for this. A newborn may have eyes that are crossed or divergent. These findings will generally self-correct within 2 months.[17] Persistent disconjugate gaze may be an indicator of an underlying vision problem or other defect of one or both eyes. It is important to detect vision issues early to attempt to prevent permanent vision loss and amblyopia. Often, if one eye is weaker than the other, the stronger eye can be patched to encourage strengthening of the weaker eye. If patching is not performed while the child is young, the risk of permanent amblyopia increases.

The iris of newborns is typically grey or blue-grey at birth in lighter skinned infants and dark grey or brown in darker skinned infants.[16] Colobomas can affect the iris as well, often giving a keyhole appearance to the iris. The presence of colobomas should prompt a full evaluation of the child as they are commonly associated with other congenital syndromes.

Areas of stromal hyperplasia surrounded by areas of hypoplasia are referred to as *Brushfield spots.* They give a speckled appearance to the iris. They can be seen in normal infants; however, more commonly, they are seen in association with Down syndrome. Approximately 90% of Down syndrome infants will have Brushfield spots.[18]

Blue scleras often make the clinician suspicious of underlying osteogenesis imperfecta. A bluish coloring of the sclera also can be seen in other connective tissue disorders such as Ehlers-Danlos syndrome. Keep in mind that "normal" newborns also may have a bluish tint to their sclera due to the sclera being thinner at that age.[16]

Following birth, subconjunctival hemorrhages very commonly are seen. These can cause significant anxiety for the parent, although they are harmless to the infant. They are formed due to a ruptured blood vessel below

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the conjunctiva and will generally resorb within 1 to 2 weeks.

The examiner may also note nystagmus on examination. *Nystagmus* is repetitive, involuntary and rhythmic movement of the eyes in one direction. It may be horizontal, vertical or rotary in nature. This should be distinguished from opsoclonus, which is rapid, irregular and nonrhythmic movement that is associated with acute febrile episodes (especially when caused by Epstein-Barr, varicella, Coxsackie and West Nile viruses) or with conditions such as neuroblastoma (where it is seen in conjunction with myoclonus).[16,19]

Nystagmus may have several causes in neonates, both benign and pathological. It can be seen due to prematurity or with retinopathy of prematurity. It also may be seen in a condition known as *transient neonatal nystagmus,* which typically will develop before age 10 months, has a mean age of onset of 2.7 months and resolves spontaneously by 1 year of age. The cause of this condition is not yet known.[20]

Eye complaints are often what brings new parents into the ED with their newborn. Silver nitrate drops used in the delivery room cause a chemical conjunctivitis in 10% of newborns. Beginning in the first 24 hours, chemical conjunctivitis presents with bilateral mild conjunctival hyperemia and mild discharge that usually resolves within 48 hours. Gram stain will be negative and no intervention is necessary. Chlamydia, causing neonatal conjunctivitis, typically has an incubation period of 1 to 2 weeks but can occur earlier due to premature rupture of the membranes. The conjunctiva becomes hyperemic and edematous with the palpebral conjunctiva more involved. Usually, only one eye is affected. Otitis media or afebrile pneumonia also may be present. Chlamydia can lead to conjunctival scarring and micropannus formation. Diagnosis can be made by identifying the chlamydial antigen, identifying intracellular inclusions from the Giemsa stain, or isolating the organism by culture from the palpebral conjunctiva of the lower lid. Gram stain typically is not useful. Oral erythromycin (40–50 mg/kg/day) for 2 to 3 weeks will eliminate colonization of both the eyes and nose. Recent studies show that prophylaxis with erythromycin ointment at birth does not decrease the incidence of chlamydial conjunctivitis.[21]

Neisseria gonorrhea has a wide-ranging incubation period, from 1 to 31 days, but clinical symptoms usually occur within the first week. It typically presents as a bilateral purulent conjunctivitis, but conjunctival hyperemia, chemosis, eyelid edema and erythema also may be present. Gram stain will reveal gram-negative intracellular diplococci. Cultures on both blood and chocolate agar should be sent for examination. Infants with gonorrheal conjunctivitis also may have evidence of rhinitis, anorectal infection, arthritis or meningitis. If gonorrheal conjunctivitis is suspected or determined, then a complete septic workup is warranted, including a lumbar puncture. Treatment includes admission for intravenous (IV) ceftriaxone or cefotaxime and frequent irrigation of the eyes. Parents should be screened for gonorrhea.[21]

Other bacteria, such as *Staphylococcus aureus, Hemophilus, Streptococcus pneumoniae, Enterococcus, Corynebacterium, Lactobacillus* or *Bacteroides* can either cause conjunctivitis or be normal flora. In such cases of infection, the conjunctiva is typically red and edematous with some exudate. Diagnosis is made by both Gram stain and culture. Broad spectrum topical antibiotics are recommended. Untreated cases of conjunctivitis may lead to corneal ulceration, perforation, scarring or bacteremia.

Viral causes of conjunctivitis in neonates also are very common, with the most likely source being family members. Usually, these infections are self-limited. Topical antibiotics can be prescribed to avoid secondary infection and to treat a possible early bacterial infection due to self-inoculation from eye-rubbing. Washing hands and not sharing towels is also important to avoid spread. Herpes simplex, on occasion, may cause conjunctivitis in newborns. Usually appearing within the first 2 weeks of life, herpes conjunctivitis will show nonspecific lid edema, conjunctival injection and serosanguineous discharge. In newborns, microdendrites and geographic ulcers are more common than the typical dendrites seen in adults. Herpes becomes colonized in the newborn during the birth process; therefore, a history of herpes infection in the parents is important to obtain so the physician can initiate preventative measures. Herpes conjunctivitis can lead to more systemic infections with higher morbidity and mortality. Conjunctival scrapings may reveal multinucleated giant cells and intranuclear inclusions. A fluorescent antibody test and viral culture should be obtained. Herpes conjunctivitis in the newborn should be treated with IV acyclovir and topical 1% trifluiridine drops or 3% vidarabine ointment.[21]

Another common eye complaint in newborns that continues into infancy is a congenital nasolacrimal duct obstruction (dacryostenosis). Failure to canalize the valve

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of Hasner is the cause. Infants present with tearing and eyelid maceration. Congenital glaucoma can present not only with tearing but also with photophobia and a cloudy enlarged cornea. Treatment of dacryostenosis includes massaging of the lacrimal sac, prophylactic topical antibiotics and warm compresses. Most ductal obstruction spontaneously resolves by 12 months of age.

EVALUATION OF THE EARS

The ears should be examined for position in relation to the eyes as well as from a top-down perspective to look for posterior or anterior set ears. *Low set ears* (defined as ears with the top of the pinna below the middle of eye level) have been associated with numerous syndromes.

Preauricular skin tags or pitting is quite common. It was once stated that any preauricular pits or skin tags required an evaluation for renal anomalies; however, after further study, it is now expressed that no further workup is needed unless there is indication of other possible anomalies during the remainder of the examination. Familial preauricular pitting has been associated with hearing loss. These patients should have their hearing screened periodically.[3] More significant otic anomalies can be associated with genitourinary anomalies. A renal ultrasound is generally indicated in any such patient.

Lastly, visualization of the tympanic membrane is difficult in newborns due to tortuous canals. Amniotic fluid may remain behind the tympanic membrane for several days to a couple of weeks after birth.

EVALUATION OF THE NOSE, MOUTH AND PHARYNX

Newborns and very young infants are obligate nose breathers. When challenged by nasal congestion from an upper respiratory infection, many newborns are unable to compensate. The newborn's normal oral intake may decline. It is important to instruct the parents how to perform bulb suctioning of the nasal passages prior to feedings and sleep. Many normal variants can be found in the mouth. Epstein's pearls, Bohn nodules and natal teeth are commonly seen. Epstein's pearls and Bohn nodules have a white or yellow appearance, giving the look of a pearl. Epstein's pearls are located near the midpalatal raphe at the junction of the hard and soft palates. Bohn nodules are located on the alveolar ridges. Both represent remnants of embryonic development of the dental lamina. These findings will resolve spontaneously and do not cause any harm to the infant while present. *Natal teeth* are defined as teeth that erupt before 30 days of life. They are seen in approximately 1 in 3000 newborns. Generally, the mandibular incisors are involved.[22] These teeth lack any significant root system, thus they ultimately fall out. They need not be removed unless there is concern for aspiration of the tooth when it dislodges or if the tooth interferes with proper feeding.[23]

Cleft lip, cleft palate or a combination of the two represent the most common newborn head and neck anomaly; only clubfoot is more common overall. Of affected infants, 46% have a combination of cleft lip and palate, whereas 21% and 33% have an isolated cleft lip or palate, respectively. Most are quite obvious; however, a finger should be inserted into the mouth to palpate the palate as submucosal clefts can be difficult to identify without palpation. Infants with a cleft should be evaluated by a plastic surgeon because surgical correction of these anomalies generally produces excellent results. Delay in correction may cause unneeded difficulties in feeding and speech development.

Occasionally, parents or even inexperienced clinicians become concerned about a mass in the throat. Many times they are seeing the tip of the epiglottis that can extend upward into visual range in the newborn. The parents need to be reassured that this is normal in order to avoid unnecessary workup.

EVALUATION OF THE NECK

An infant with positional plagiocephaly should be evaluated for underlying congenital muscular torticollis (CMT), seen in 1 in 250 live births.[24] An infant with CMT presents with his or her head flexed and chin turned opposite the affected muscle. Approximately two-thirds of patients with CMT have a palpable mass in the affected muscle. When plagiocephaly is present, detection of CMT is important as uncorrected torticollis beyond 1 year of age tends to lead to persistent plagiocephaly.[25] Physical therapy generally is curative. Rarely, surgical intervention is needed. Recognition of this condition is important because plagiocephaly has an increased risk of becoming permanent if the torticollis is not corrected by age 1 year.[25]

Branchial cleft cysts, sinuses or other anomalies can present in the neck as well. The neck needs to be examined closely for any remnants of the branchial clefts or arches.

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These may be found involving the pinna of the ear, the preauricular area or the lateral neck. Several syndromes are associated with branchial cleft anomalies, including Goldenhar syndrome and Pierre Robin syndrome.

Occasionally, a thyroglossal duct cyst that has become infected may present as a central neck cellulitis. Midline neck lesions should prompt examination for an underlying thyroglossal duct cyst.

EVALUATION OF THE CHEST AND LUNGS

When examining the chest, it is important to not become fixed on the lung sounds; the remainder of the chest should be evaluated for any possible anomalies as well. The clavicles should each be palpated for any feeling of crepitus or malalignment that may indicate a clavicle fracture. Clavicle fractures occur in 0.2% to 3.5% of births.[26] Fortunately, even severely angulated clavicle fractures will heal very well with no intervention. Parents should be instructed on the use of pain medications for their baby. Pain should subside quite quickly.

Newborns of both genders can develop breast enlargement and neonatal acne due to maternal hormones. These hormones also can cause vaginal bleeding in newborn girls. This triad has been termed *puberty of the newborn period.* Parental reassurance as to why this occurs is the only treatment that is needed. Occasionally, mastitis may develop in the newborn breast tissue. Any newborn diagnosed with mastitis should be admitted to the hospital for IV antibiotics. Choice of antibiotic should include methicillin-resistant *S. aureus* coverage as this organism appears to be increasing in frequency in the newborn period.[27] If an abscess is suspected, surgical consultation is mandatory.Much information can be gained about the respiratory status of a neonate by observing the chest while the infant is breathing. Chest movement should be symmetrical. Subcostal, suprasternal and intracostal retractions should be noted. So-called abdominal breathing can be a sign that the young infant is working harder to breathe. Nasal flaring and grunting also indicate respiratory distress. Fever and tachypnea may indicate an underlying pneumonia. Infants presenting with tachypnea, an increased oxygen requirement and lack of hypercapnia shortly after birth are likely to be experiencing transient tachypnea of the newborn (TTN). TTN is seen in approximately 0.3% to 0.5% of newborns and will resolve within 24 to 72 hours.[28] Infants with TTN-like symptoms that do not resolve within this time period should be reevaluated for a different cause of respiratory distress.

Periodic breathing is defined as periods of rapid breathing followed by short pauses. The pauses are not associated with mental status change, color change or limpness. Periodic breathing occurs in "normal" newborns. It can occur more often when newborns and young infants are tired or ill. Periodic breathing can be mistaken for apnea. *Apnea* is defined as a cessation of breathing that is either longer than 20 seconds or associated with cyanosis, mental status change or limpness. Any newborn diagnosed with apnea needs to be admitted to the hospital for a complete workup. Apnea can be caused by a variety of conditions, including sepsis, respiratory infections such as pertussis or respiratory syncytial virus (RSV), or apnea of prematurity.

EVALUATION OF THE CARDIOVASCULAR SYSTEM

Significant transitions occur within the cardiovascular system at the time of birth. Prior to birth, the infant is not using the lungs for ventilation, thus blood flow is generally shunted away from the lungs and back to the body. This occurs due to an elevated pulmonary blood pressure, a patent ductus arteriosus and a patent foramen ovale. At birth, the lungs need to become fully active and these bypass systems must adjust. As the lungs expand, the pulmonary pressures begin to drop. This transition lowers the right atrial pressure, allowing the foramen ovale to close. The ductus arteriosus typically will functionally close 10 to 15 hours after birth but may not fully fuse for up to 3 weeks.[29] Infants who require the ductus to be open to maintain systemic circulation, as in some individuals with congenital heart diseases, may not begin to close their ductus until days after birth. When this delayed closure finally occurs, the newborn typically will present with cyanosis or poor systemic cardiovascular perfusion (see Chapter 15). Pulmonary pressures typically continue to fall for 4 to 6 weeks after birth. Because of this, a newborn typically has a single S2 that becomes physiologically split as pressures fall. S1 is typically single and loudest near the apex of the heart. Additionally, near the apex, an S3 may be heard and is considered normal in infants. An S4 is not considered normal in neonates and should be evaluated further. Infants often have quite rapid heart rates that can make distinguishing heart sounds difficult. If in doubt, evaluation is prudent. Pulses

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should be palpated in all four extremities, noting their strength and regularity. Diminished pulses in the lower extremities may be an indication of coarctation of the aorta.

The newborn cardiac examination can reveal many murmurs that may or may not be considered innocent. Very commonly, a flow murmur can be heard. This murmur is a systolic ejection murmur and has a vibratory or musical sound to it. It is often heard best in the lower left sternal boarder area. This and other innocent murmurs are typically soft (I-II/VI in strength) and generally do not radiate.

A machinelike murmur that is heard just below the left clavicle is likely to be a patent ductus arteriosus (PDA) murmur. This murmur is often described as a continuous murmur that waxes and wanes in volume. As pulmonary pressures drop, a PDA murmur may become more prominent.

Murmurs that are harsh sounding are less likely to be physiologic. Holosystolic or diastolic murmurs are never innocent and should be evaluated. Most commonly, a holosystolic murmur is due to a ventricular septal defect (VSD). VSDs represent 15% to 20% of congenital cardiac defects.[30] The classic holosystolic murmur of the VSD may be absent at birth due to increased right-sided cardiac pressures preventing significant blood flow across the VSD. As pulmonary pressures decrease, blood flow increases and the murmur becomes apparent.

Many congenital syndromes are associated with predictable cardiac defects. When these defects are found, an underlying syndrome should be considered. As an example, 30% of patients with a complete atrioventricular septal defect (AVSD) have Down syndrome.[30]

If concern about the cardiovascular system exists, evaluation typically includes a chest x-ray, electrocardiogram (ECG) and echocardiogram. Just as vital signs vary with age, ECG standards vary as well. Tables of standard ECG values should be consulted when interpreting pediatric ECGs to ensure aberrations are not missed (see Chapter 15).

EVALUATION OF THE ABDOMEN

The assessment of the newborn abdomen includes the same components as with older children. The areas of the liver, spleen and kidneys are palpated.. The newborn liver edge frequently is located approximately 1 cm below the right costal margin. This extension is normal. At 1 week of age, a normal liver span is 4.5 to 5 cm.[31] Tables of normal liver spans for age exist and can be consulted, if needed. The liver edge is examined using the flats of the fingers as they are more sensitive to masses than the fingertips. Palpation should start in the left lower quadrant and move slowly to the right upper quadrant to avoid missing a dramatically enlarged liver.

The spleen should not be palpable, in general. It may become enlarged and palpable in several conditions that can present in the newborn. Any of the hemolyzing states, such as rhesus factor (Rh factor) or ABO incompatibility, or red cell defects, such as spherocytosis, can result in an enlarged liver. Typically, these are accompanied by prolonged or severe jaundice.

If the kidneys are enlarged, they are often easily palpable. (Note that it is often possible to palpate a normal kidney because infants have a compliable abdominal compartment.) Cystic or enlarged kidneys can be quite large at birth. If the kidneys are enlarged bilaterally, autosomal recessive polycystic kidney disease should be considered.[32]

The umbilical cord of a newborn should be inspected. A normal umbilical cord should have two arteries and one vein. Approximately 0.2% to 1% of newborns have a single umbilical artery. It has been shown that these infants have a three- and sixfold higher incidence, respectively, of severe renal anomalies and renal malformations compared with the general population.[33,34]

Often, parents complain of discharge or odor around the infant's healing umbilicus. Most often this is due to inadequate cleaning of the area. Parents should be instructed on good umbilical hygiene. Any nonhealing granulation tissue that remains after the cord falls off can be treated with silver nitrate application; it is important to avoid getting silver nitrate on the surrounding normal skin. Any redness surrounding the umbilical area should be considered the bacterial infection, omphalitis until proven otherwise. Etiology includes both gram-positive and gram-negative organisms such as *S. aureus*, group A Streptococcus, *Escherichia coli, Klebsiella pneumoniae* and *Proteus mirabilis.*

Newborns at higher risk for umbilical infection include those with premature rupture of membranes and those with umbilical catheterization. Other risk factors include patent urachus and immunodeficiency. Omphalitis is of concern as the infection may progress

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to fascial planes (necrotizing fasciitis), abdominal wall musculature (myonecrosis) and the umbilical and portal veins (phlebitis). Mortality rates are high, estimated at 7% to 15%. Admission to the hospital is mandatory. IV antibiotics such as oxacillin and gentamicin provide good gram-positive and gram-negative coverage. Recently, however, methicillin-resistant *S. aureus* has increased in frequency in the newborn period, thus better coverage may include vancomycin and gentamicin.[27] If more extensive infection is present, such as necrotizing fasciitis or myonecrosis, then anaerobic coverage should be added with metronidazole or clindamycin. If an abscess is present, then surgical consultation is also recommended.[35] The umbilical cord usually dries up and falls off within the first 2 weeks after birth. An umbilical cord that is still present after 4 weeks is of concern because it may indicate an immunodeficiency and should be investigated. A continuous or intermittent clear yellow discharge from the umbilicus also may be a sign of a patent urachus or urachal sinus. Crying, voiding, straining or lying in the prone position can increase the discharge. Evaluation of the fluid for urea or creatinine can prove the presence of urine. A patent urachus may be associated with a bladder obstruction due to posterior urethral valves. Ultrasound or a voiding cystourethrogram (VCUG) can be used to make the diagnosis. The patent tract may become inflamed with tenderness, swelling and a serosanguinous or purulent discharge. A patent ductus can be observed as some may spontaneously resolve in the first 2 months of life. Umbilical hernias also may be present at birth. These rarely produce incarceration of the bowel and most resolve by the age of 1 year. Parents should be discouraged from using home remedies such as the taping of a coin or abdominal binders on the newborn. If an umbilical hernia is still present when the infant is 1 year old, he or she can be referred to a pediatric surgeon for hernia repair. Infants with a congenital diaphragmatic hernia (CDH) may present with a scaphoid abdomen at birth. If CDH is suspected, the infant should be immediately intubated at birth to prevent introduction of air into the stomach, which may increase pressure on the lungs and mediastinum. Note that absence of a scaphoid abdomen does not rule out CDH. CDHs can, on occasion, present several weeks to months after birth, often when a significant lower respiratory tract infection such as RSV or pneumonia compromises the young infant.Rarely, an absence of the abdominal musculature may be seen. In combination with cryptorchidism and urinary tract anomalies, this condition is termed *prune belly syndrome* or the *Eagle-Barrett triad.* It occurs in 1 in 40,000 births; 95% of cases are found in males.[36]

EVALUATION OF THE GENITOURINARY TRACT

As this area is generally covered by the diaper, it may not get a proper evaluation; however, there are numerous genitourinary tract anomalies that are important to identify if present. Male infants should be evaluated for hypospadius or other urethral anomalies, inguinal hernias, varicoceles, hydroceles and undescended testes. The cremasteric reflex can be quite strong in infants. This reflex pulls the testes into the inguinal canal, which can give the impression of an undescended testis. In patients with a strong reflex, the testis can be brought fully into the scrotum. In approximately 3% to 4% of boys, the testis truly is not able to be brought fully into the scrotum at birth (termed *cryptorchidism*). By age 1 year, most testes have descended; only 0.3% remain undescended.[32] True undescended testes have a four- to tenfold higher risk of developing a malignancy (most commonly a seminoma) than do descended testes.[32] For this reason, the testis should be surgically brought down into the scrotum to allow for easy examination and earlier detection of masses.

Varicoceles and hydroceles can present with an enlarged scrotum. Varicoceles are often described as feeling like a "bag of worms" in the scrotum. They develop from a dilation of the pampiniform plexus and internal spermatic vein. They are more commonly seen on the left and when the infant is upright. Varicoceles should reduce easily with constant pressure while the infant is lying flat. If the varicoceles will not reduce or are found on the right, there should be suspicion of venous blockage. This may be indicative of an abdominal mass. Abdominal ultrasound is a fast, painless, noninvasive way to evaluate for this.[37]

Hydroceles can be distinguished easily from a varicocele or hernia by transillumination. A hydrocele is formed when the processus vaginalis fails to close fully but closes enough to prevent bowel herniation. Only fluid is allowed to enter the scrotum. This fluid easily transilluminates. Rarely, bowel also may transilluminate, giving the impression of a hydrocele, but palpation is likely to help distinguish the two. If necessary, ultrasound can be used to verify the diagnosis. Hydroceles resolve spontaneously by age 12 to 28 months in most cases.[38] Those that do not

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