Birth Injuries in Neonates

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Education Gaps

1. Clinicians should understand the outcome of birth-related extracranial and intracranial injuries and the most appropriate time of intervention.
2. Clinicians should understand the outcome of long bone fractures that occur during the birth process.
3. Clinicians should understand when to consult with neurosurgery when faced with a depressed skull fracture after a birth and be familiar with clinical outcomes.
4. Clinicians should understand the outcome of facial nerve injury and brachial plexus injury resulting from birth trauma.
5. Clinicians need to understand the medicolegal implications of birth injuries and the importance of careful documentation.

Objectives

After completing this article, readers should be able to:

1. Discuss delivery conditions that increase the risk of birth injuries.
2. List favorable and unfavorable outcomes following birth injuries.
3. Describe common birth injuries and delineate current evaluation and management from the general pediatric practitioner's perspective.
4. Focus on emergency situations that involve traumatic bleeding; nerve injury; and fractures of the skull, clavicles, and long bones that require urgent assessment and intervention.

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INTRODUCTION

Birth injury is defined as the structural destruction or functional deterioration of the neonate's body due to a traumatic event at birth. Some of these injuries are avoidable when appropriate care is available and others are part of the delivery process that can occur even when clinicians practice extreme caution. Amniocentesis and intrauterine transfusions can cause injuries before birth, and these and any injuries that occur following neonatal resuscitation procedures are not considered birth injuries. However, injuries occurring from fetal scalp electrodes and intrapartum heart rate monitoring *are* considered birth injuries. Over the past

20 years, the number of deaths due to birth injuries has declined such that they no longer are listed in the 10 most common causes of death in the neonatal period.

RISK FACTORS FOR TRAUMATIC BIRTH INJURY

Macrosomia has been a well-known risk factor for traumatic birth injury. The degree of risk changes with the degree of macrosomia. If the birthweight is 4,000 to 4,500 g, the risk of birth injuries increases twofold. If the weight is 4,500 to 4,900 g, the risk increases threefold, and if the weight is more than 5,000 g, the risk increases more than 4.5-fold. The risk of traumatic birth injury due to macrosomia does not change with the route of delivery. Poorly controlled maternal diabetes is one of the major causes of macrosomia.

Instrumental deliveries such as forceps and vacuum extraction are also major risk factors for birth injuries. Forceps use is associated with a fourfold increase in the chance of birth injuries and vacuum extraction with a threefold increase compared to unassisted vaginal deliveries. Demisse et al (1) stated in 2004 that the risk for cephalohematoma increases with the use of instruments; it is 4 to 5 times higher with the use of forceps, 8 to 9 times higher with the use of vacuum, and 11 to 12 times higher with use of forceps and vacuum in combination compared to unassisted deliveries. Lyons et al (2) noted in 2015 that the rate of birth injuries for infants with breech presentation born by cesarean delivery without a trial of labor is 6 per 1,000 live births, by cesarean delivery with labor is 10 per 1,000 live births, and by vaginal delivery is 30 per 1,000 live births. Vaginal delivery is a substantial risk factor for specific, as well as all-cause, birth injury. Other risk factors and related injuries are listed in Table 1.

SOFT-TISSUE INJURIES

Erythema and Abrasions

These injuries occur when there is dystocia (abnormal fetal size or position resulting in a difficult delivery) of the presenting part during labor. When forceps are applied, these injuries are linear at the site of forceps application. Any soft-tissue area affected by birth injury should be managed hygienically to minimize secondary infections. Most injuries are self-limited and usually do not require treatment unless complications occur.

Petechiae

Petechiae are observed when there is a tight nuchal cord, a precipitous delivery, or a breech presentation. Tightening of a nuchal cord causes a sudden increase in venous pressure that can lead to pinpoint capillary rupture in affected areas. With the release of such pressure, typically no further petechiae develop unless there is thrombocytopenia after delivery. In the presence of infection, however, additional signs are evident (eg, temperature irregularity, cardiopulmonary distress) that can help distinguish traumatic from infection-related petechiae. Petechiae associated with disseminated intravascular coagulation exhibit signs such as oozing of blood from various sites, abnormal coagulation profiles, and thrombocytopenia that typically leads to a more generalized than focal petechial distribution.

A detailed family history and history of birth injury in any prior pregnancies is important. During physical examination, the clinician should pay specific attention to the location and distribution of the petechiae and any sites of active bleeding. Localized petechiae are usually associated with birth injuries, as is active bleeding. No specific treatment

TABLE 1. **Risk Factors for Birth Trauma and Associated Injury**

RISK FACTORS	RELATED INJURIES
Forceps delivery	Facial nerve injuries
Vacuum extraction	Depressed skull fracture, subgaleal hemorrhage
Forceps/vacuum/forceps + vacuum	Cephalohematoma, intracranial hemorrhage, shoulder dystocia, retinal hemorrhages
Breech presentation	Brachial plexus palsy, intracranial hemorrhage, gluteal lacerations, long bone fractures
Macrosomia	Shoulder dystocia, clavicle and rib fractures, cephalohematoma, caput succedaneum
Abnormal presentation (face, brow, transverse, compound)	Excessive bruising, retinal hemorrhage, lacerations
Prematurity	Bruising, intracranial and extracranial hemorrhage
Precipitous delivery	Bruising, intracranial and extracranial hemorrhage, retinal hemorrhage

is necessary for traumatic petechiae; they usually disappear within the first few days after birth.

Ecchymoses and Bruising

Ecchymoses and bruising occur more with traumatic and breech deliveries. There is an increased risk of hyperbilirubinemia with these injuries. The incidence of ecchymoses and bruising is greater in preterm than term infants. Ecchymoses may reflect blood loss when extensive and should prompt a search for occult sites of internal bleeding. Jaundice occurs over the 3 to 5 days after birth as the extravasated blood is degraded and its byproducts cleared. Most ecchymoses due to birth injury resolve spontaneously within 1 week.

Subcutaneous Fat Necrosis

A specific form of panniculitis that is seen most commonly in term and postterm newborns occurs because of focal pressure and ischemia to adipose tissue within the subcutaneous space during the birth process. Subcutaneous fat necrosis is hard and well-circumscribed. Usually it is surrounded by erythema, but it can be flesh-colored or blue. Resolution occurs spontaneously by 6 to 8 weeks of age. Affected infants require long-term follow-up evaluation for the development of hypercalcemia, which can occur up to 6 months after the initial presentation of the skin lesions.

The exact pathogenesis of the hypercalcemia is unknown. Several hypotheses have been suggested in the literature. Granulomatous infiltrate forms in the tissue after the development of solidification and necrosis. Some reports suggest that 1-α hydroxylase has been found in the granulomatous infiltrate that converts 25-hydroxyvitamin D to 1,25-dihydroxycholecalciferol, which, in turn, increases calcium absorption from the intestine and mobilizes calcium from bone, leading to hypercalcemia. Elevated prostaglandin levels have also been reported to cause hypercalcemia in these patients through unknown mechanisms. The release of calcium from necrotic fat cells into the blood and increased calcium mobilization from bone as a result of increased parathyroid hormone activity have also been postulated as mechanisms for hypercalcemia.

Lacerations

Lacerations usually occur from scalpel use during vaginal or cesarean deliveries. The most common sites are the scalp, the gluteal region, and the thigh. Following an operative delivery with superficial lacerations, adhesive tape across the laceration is usually sufficient to initiate the process of healing and control bleeding. Deep lacerations require suturing. Rarely, a skull fracture may underlie the laceration and can cause excessive bleeding, leading to an emergency. Dessole et al (3) reported in 2004 that an increased rate of lacerations occurred when an emergent cesarean delivery was performed for fetal distress compared to other emergent indications, and lacerations were much less frequent in scheduled cesarean deliveries. Most lacerations occur with cephalic presentation, which increases the risk of facial lacerations, compared to transverse or breech presentation. Mild lacerations that are restricted to the skin are most common. Moderate lacerations that include both skin and muscle layers and severe lacerations that involve skin, muscle, bone, and nervous tissue are much less common.

CRANIAL INJURIES

Extracranial Injuries

Cephalohematoma. Cephalohematoma (Fig 1) is caused by a subperiosteal collection of blood due to rupture of vessels beneath the periosteum. It occurs in 1% to 2% of all deliveries, regardless of mode, and does not cross the suture lines because the bleeding is within a single cranial plate.

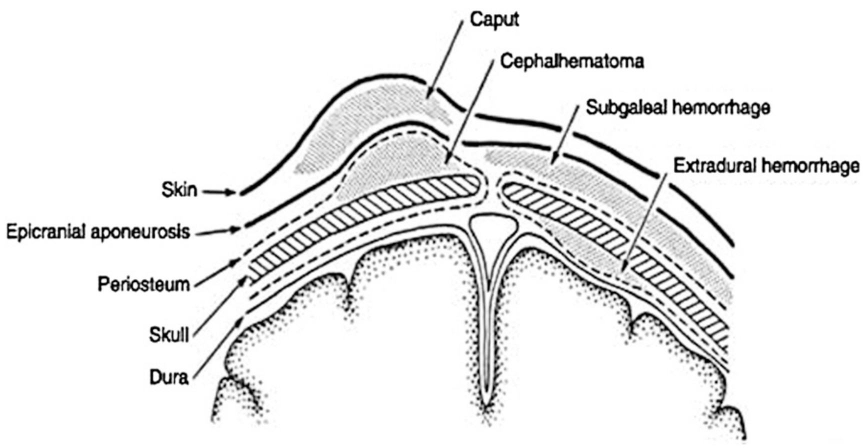

Figure 1. Extradural fluid collections. Reprinted with permission from Volpe JJ. Injuries of extracranial, cranial, intracranial, spinal cord, and peripheral nervous system structures. In: Volpe JJ, ed. *Neurology of the Newborn*. 4th ed. Philadelphia, PA: WB Saunders; 2001:813. © Elsevier 2001.

Hence, cephalohematoma is often unilateral. Usually it is not associated with substantial blood loss. Swelling generally is not apparent for several hours to days because the bleeding is slow. On physical examination, the affected area is typically largest on postnatal day 3. Sharply demarcated boundaries may be palpable, and the possibility of an underlying skull fracture can be ruled out by skull radiography or computed tomography (CT) scan. Cephalohematomas resolve over the course of 3 to 4 weeks, although calcification may be present thereafter, leaving a palpable subcutaneous nodule until it is resorbed over 3 to 4 months.

Two other conditions might be confused with cephalohematomas. Cranial meningocele can be differentiated by visible or palpable pulsations, an increase in pressure when the newborn cries, and bone lucency visible on skull radiography. In some cases, cephalohematomas may become infected and result in osteomyelitis of the skull. *Escherichia coli* is reported as the most common causative agent. Infected cephalohematomas appear erythematous and are fluctuant; swelling can be seen on cranial CT scan or magnetic resonance imaging (MRI). Needle aspiration should be considered in suspected cases of infection. Cephalohematoma is differentiated from caput succedaneum by the sharp demarcation and periosteal limitation to a single bone, absence of discoloration of the overlying skin, the timetable for the swelling (caput occurs at birth and cephalohematoma evolves over 24 hours or more), and the longer period of time for resolution.

Caput Succedaneum. During labor, increased pressure of vaginal and uterine walls on the fetal head results in accumulation of blood and serum above the periosteum and below the skin, leading to caput succedaneum (Fig 1). This injury causes edematous swelling of the scalp above the periosteum after bleeding occurs. Caput succedaneum is exterior to the periosteum and extends across the midline of the skull and across suture lines. Because the swelling is under the skin, it leads to overlying erythema, petechiae, and ecchymoses.

Caput succedaneum can be difficult to differentiate when it is bilateral. Careful examination and palpation to discern if the bleeding is external to the periosteum is necessary to differentiate caput succedaneum from cephalohematoma. Iatrogenic encephalocele is an infrequent complication of vacuum extraction delivery and may present similarly to caput succedaneum initially. Imaging should be considered in every child who has a large caput succedaneum that does not diminish in 48 to 72 hours or with enlargement of the swelling more than 24 hours after delivery, especially when there are neurologic deficits and hemodynamic instability. Usually no specific treatment is indicated. Caput succedaneum typically resolves in 4 to 6 days.

Subgaleal Hemorrhage. Subgaleal hemorrhage (SGH) is a collection of blood between the epicranial aponeurosis and periosteum of skull (Fig 1). The incidence is 4 in 10,000 noninstrumented deliveries and 64 in 10,000 vacuum extraction deliveries. SGH can readily result in sequestration of 40% or more of the newborn's blood volume and cause hemorrhagic shock. Mortality may be as high as 14% from shock and the associated coagulopathy. Infants who have experienced a difficult operative delivery requiring forceful manual and/or instrumental manipulation may have had shearing injury to the emissary veins that are responsible for draining the dural sinus and lie within the space between the epicranial aponeurosis and periosteum of skull (Fig 2). Infants with a suspected SGH require ongoing monitoring of

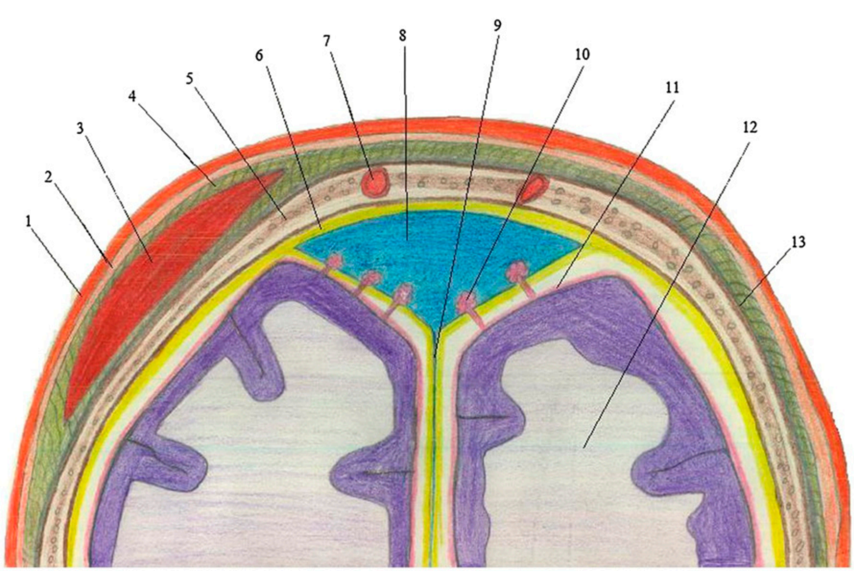

Figure 2. Cerebral, cranial, subcutaneous, and cutaneous layers of the head. 1. Skin, 2. Connective tissue, 3. Subgaleal hematoma, 4. Galea aponeurotica, 5. Calvaria, 6. Dura mater, 7. Emissary vein, 8. Superior sagittal sinus, 9. Falx cerebri, 10. Subarachnoid granulation, 11. Pia mater, 12. Cerebral hemisphere, 13. Loose areolar tissue. Adapted from Mouhayar J, Charafeddine L. Index of suspicion in the nursery. Head swelling and decreased activity in a 2-day-old term infant. *NeoReviews*. 2012;13(10):e615–e617.

vital signs and serial measurements of both hematocrit and occipital frontal circumference (OFC).

A classic triad of clinical findings for SGH includes tachycardia, a falling hematocrit, and increasing OFC in the first 24 to 48 hours after birth. The bleeding can extend circumferentially and only be limited by the orbital ridges anteriorly, the temporal fascia laterally, and the nape of the neck posteriorly. The OFC may increase by 1 cm for every 30 to 40 mL of blood sequestered in this space. Palpation of the head reveals bogginess of the subcutaneous tissue; at times, there is even fluctuance during the first 24 to 48 hours.

Head imaging, using either CT scan or MRI, can be useful in differentiating SGH from other pathologic cranial conditions. Coagulation studies are required to detect the consumptive coagulopathy that may be associated with SGH. Treatment includes volume resuscitation with packed red blood cells, fresh frozen plasma, and normal saline as appropriate for ongoing bleeding and correction of coagulopathy. Rarely, brain compression requiring surgical evacuation of the hematoma is reported. The treatment plan for SGH is outlined in Table 2.

Intracranial Injuries

Subdural Hemorrhage. The incidence of subdural hemorrhage (SDH) is 2.9 per 100,000 spontaneous deliveries. It doubles with vacuum or forceps use and is 10 times higher if both vacuum and forceps are used in delivery assistance. If cesarean delivery is performed, the incidence is higher if the procedure is undertaken after a trial of labor compared to no labor and cesarean delivery. SDH describes bleeding between the dura mater and the arachnoid layer of brain. It is caused by rupture of bridging veins and is the most common intracranial hemorrhage in term newborns. The most common location for SDH is interhemispheric or tentorial.

Affected infants may become symptomatic in the first 24 to 48 hours after birth. Presenting findings generally include respiratory depression, apnea, and/or seizures. In addition, there may be signs of neurologic dysfunction such as irritability and an altered level of consciousness. The management of SDH depends upon the location and extent of the bleeding. Most infants can be closely observed without surgical intervention. This is possibly due to the plasticity of the neonatal skull, which allows for some degree of expansion without development of increased intracranial pressure. Surgical evacuation is necessary for infants with SDH who exhibit signs of increased intracranial pressure (Fig 3).

Posterior fossa SDH in neonates is relatively rare (Fig 4). Substantial SDH in the posterior fossa, however, may result in death due to compression of the respiratory centers in the brainstem. Excessive fetal head molding during the birthing process can be an important clue to diagnosing posterior SDH. Treatment is generally supportive, including correction of any coagulopathy and cardiopulmonary support. Neurosurgical consultation may be prudent if there is severe hemorrhage, brainstem dysfunction, or hydrocephalus.

Head ultrasonography is a safe and readily available bedside tool that is often performed before definitive studies (eg, CT scan, MRI) because recent safety trends encourage

TABLE 2. **Management and Treatment for Subgaleal Hemorrhage**

1. Immediately place a line for central venous access (umbilical venous line).
2. Place an umbilical arterial line to draw blood and measure blood pressure.
3. Replace volume loss aggressively (10-20 mL/kg bolus infusions). Use normal saline, whole blood, or packed red blood cells.
4. Anticipate a 40-mL blood loss for every 1-cm increase in occipital frontal circumference.
5. Consider sodium bicarbonate correction for metabolic acidemia (1-2 mEq/kg).
6. Provide adequate oxygenation: oxygen, continuous positive airway pressure, assisted ventilation.
7. Monitor serial hematocrits and evaluate for coagulopathy. Transfuse as indicated with packed red blood cells, fresh frozen plasma or cryoprecipitate, and platelets as indicated.
8. Maintain accurate monitoring of fluid intake (volumes given) and urinary flow.

Adapted from Rosenberg. (4)

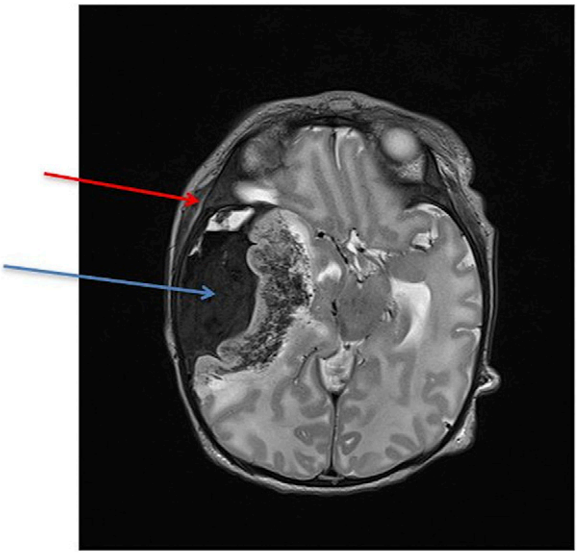

Figure 3. Magnetic resonance imaging of term infant with right-side subdural hemorrhage (blue arrow) who presented with seizures requiring surgical decompression within 24 hours after birth due to midline shift and extent of hemorrhage. The dural layer is indicated with the red arrow. Courtesy of Children's Mercy Hospital, Kansas City.

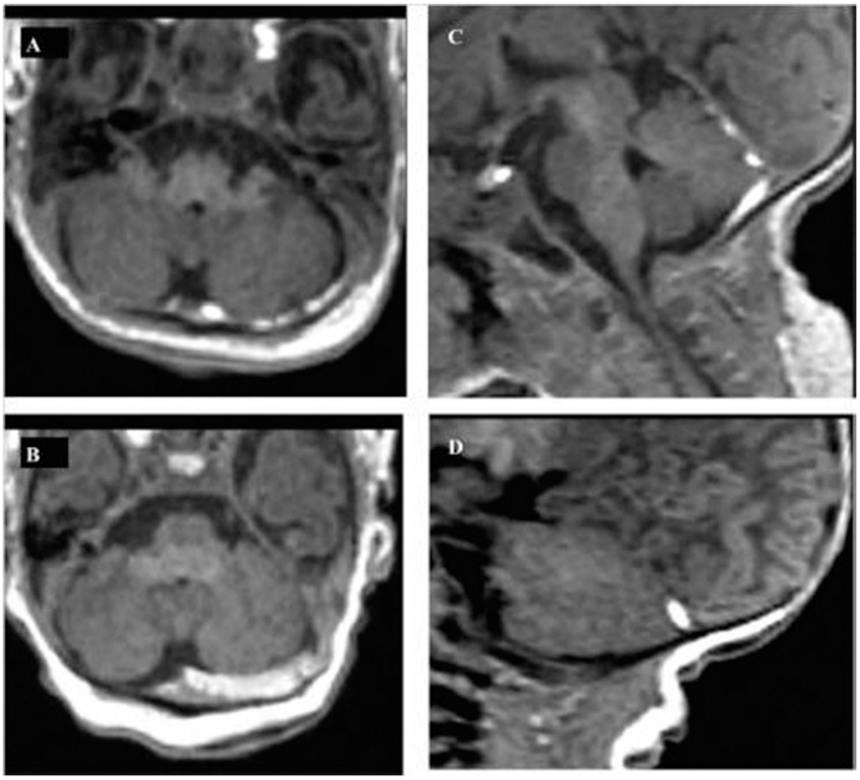

Figure 4. Posterior fossa subdural hemorrhage (SDH) on T1-weighted magnetic resonance scans in 4 different patients. A. Axial small SDH left cerebellar convexity. B. Axial larger SDH left cerebellar convexity. C. Sagittal small SDH below tent and posterior to cerebellum. D. Sagittal small SDH below tent, off midline. Reprinted from Kelly P, Hayman R, Shekerdemian LS, et al. Subdural hemorrhage and hypoxia in infants with congenital heart disease. *Pediatrics*. 2014;134(3):e773–e781.

reduced radiation exposure by using fewer CT scans. In the hands of an experienced sonographer or radiologist, a high-quality image can detect significant intracranial hemorrhage and facilitate management, if needed.

Epidural Hematoma. Epidural hematoma is very rare in neonates and is caused by injury to the middle meningeal artery. Most cases also involve a corresponding linear skull fracture. Presenting signs include hypotonia, seizures, bulging fontanelles, and a change in the neonate's level of consciousness. Diagnosis is usually made by head CT scan. Close observation may be all that is necessary, specifically monitoring for signs of herniation. If such signs are found, surgical evacuation is necessary.

Subarachnoid Hemorrhage. This is the second most common intracranial hemorrhage in neonates. According to reports, many newborns acquire a subarachnoid hemorrhage (SAH) during the birth process but remain asymptomatic, with eventual resolution after several days. SAH is caused by rupture of bridging veins in the subarachnoid space. Symptoms appear at 24 to 48 hours after birth and may include apnea or seizures. If the cause of apnea or seizures is not obvious and if determination of cause is difficult, SAH should be suspected and a CT scan of the brain pursued. Close monitoring may be all that is necessary, but if signs of herniation are encountered, surgical evacuation is warranted.

Intraventricular Hemorrhage. Although intraventricular hemorrhage (IVH) is usually associated with preterm delivery, IVH is also reported as a consequence of birth injury in term infants. In a study of 505 healthy asymptomatic term infants who underwent head ultrasonography within 72 hours of birth, the incidence of IVH was 4%. All of the hemorrhages were subependymal (grade 1 IVH). The risk of IVH increases with operative deliveries, with reported incidences per 10,000 deliveries of 1.1, 1.5, 2.6, and 3.7 for spontaneous, vacuum-assisted, forceps-assisted, and combined vacuum- and forceps-assisted deliveries, respectively.

Retinal Hemorrhage. Retinal hemorrhage occurs in approximately 75% of vacuum deliveries, 33% of spontaneous vaginal deliveries, and 6.7% of cesarean deliveries. The exact cause is unknown, but the lower incidence associated with cesarean deliveries suggests that pressure exerted on the head during passage through the birth canal can be the cause. The chances for finding retinal hemorrhages are highest if a funduscopic examination is performed within the first 24 hours after birth. Retinal hemorrhages related to the birth process can be seen up to 3 to 4 weeks after birth, but other causes such as nonaccidental injury should be considered after that time period. Associated optic nerve injury increases the risk of visual impairment in infants with retinal hemorrhages.

NERVE INJURIES

Facial Nerve Injury

The incidence of facial nerve injury is 0.5% to 1% of live births. The injury usually results from compression of the peripheral branches of the facial nerve by forceps; agenesis of the facial nerve nucleus (eg, Mobius syndrome) is much less common. The mandibular branch of the facial nerve is most commonly affected, resulting in less muscle contraction on the affected side. Loss of the nasolabial fold, partial closing of the eye (ptosis), and the decreased ability to contract the lower facial muscles on the affected side with the appearance of a "drooping" mouth are common features. The mouth is drawn over to the unaffected side with crying (Fig 5). Traumatic facial palsies resolve in 2 to 3 weeks.

Facial nerve palsy should be differentiated from other causes of an asymmetric crying face (ACF). The examiner can make this differentiation by noting that the eye and forehead muscles are unaffected with ACF. A common cause of ACF is a congenital deficiency or absence of the depressor anguli oris muscle, which controls the downward motion of the lip. In rare cases, this anomaly has been associated with cardiac or renal abnormalities or 22q11 deletion.

Brachial Plexus Injury

The incidence of brachial plexus injuries is 0.5 to 2.5 per 1,000 live births. Brachial plexus injury involves paralysis of upper arm muscles following trauma to spinal roots C5 to T1

Figure 5. Facial nerve injury. This newborn was delivered by forceps-assisted vaginal delivery. Although not visible in the photo, there were small abrasions present on the left lateral eyelid and anterior to the right ear. The right facial nerve is affected. In an infant who is crying, the entire lower lip should be pulled down by the action of the facial nerve, but in this infant, the lip is pulled down only on the left and an asymmetry results. Spontaneous resolution is expected. Courtesy of Janelle Aby, MD, Lucille Packard Children's Hospital at Stanford.

(Fig 6). Risk factors for this type of injury include shoulder dystocia, macrosomia (birthweight >4,500 g), difficult delivery, breech presentation, and instrumented deliveries. There are 4 forms of brachial plexus injury:

- Erb-Duchenne palsy: injury to C5-6, most common form of brachial plexus palsy
- Klumpke palsy: injury to C8 to T1
- Total arm paralysis: if all nerve roots are involved
- Horner syndrome: miosis, ptosis, and enophthalmos; damage to sympathetic outflow via nerve root T1

Brachial plexus injury is diagnosed by the presence of unilateral arm weakness. In Erb palsy, the arm retains a position of adduction and internal rotation, fully extended at the elbow, with pronation of the forearm and flexion of the wrist (Fig 7). Testing the Moro (startle) reflex in an affected infant produces arm movement asymmetry because the affected arm does not rise as high as the unaffected arm. An adequate grasp reflex in Erb palsy excludes total arm paralysis. Most brachial plexus injuries of this type resolve spontaneously. Improvement in movement can often be noted within the first 24 hours of birth. Brachial plexus palsy can be associated with phrenic nerve palsy. If a newborn with brachial palsy has tachypnea and requires oxygen, the possibility of phrenic nerve involvement increases and ultrasonographic studies of hemidiaphragmatic movement may be indicated.

The diagnosis of a brachial plexus injury is clinical. Once the diagnosis is made, physical therapy should be started and continued weekly for at least 3 months. If there is no improvement in the range of motion at that time, concern for brachial plexus nerve root avulsion should be raised and an orthopedic surgeon consulted for further evaluation. Nerve reconstruction remains controversial, although newborns with possible avulsion are eligible. Nerve reconstruction is generally undertaken at or beyond age 6 months. Botulinum toxin has been used to treat patients who are older and have contractures. Initial pain management is also an important aspect of caring for affected neonates. Treatment goals for pain include: 1) reducing the pain with oral medications, 2) determining the substituted movement patterns that are causing the pain, and 3) teaching the parents to move the infant's trunk and extremities in a way that minimizes both pain and overuse of the adjacent joints during a particular task. Generally, infants "self-splint," holding the affected arm in a comfortable position. The newborn's prognosis for recovery varies greatly, from 0 to 90%, and depends upon the extent of nerve root involvement. The Gilbert and Tassin/Narakas classification scheme can be used to grade the severity of brachial plexus injury and prognosticate recovery (5).

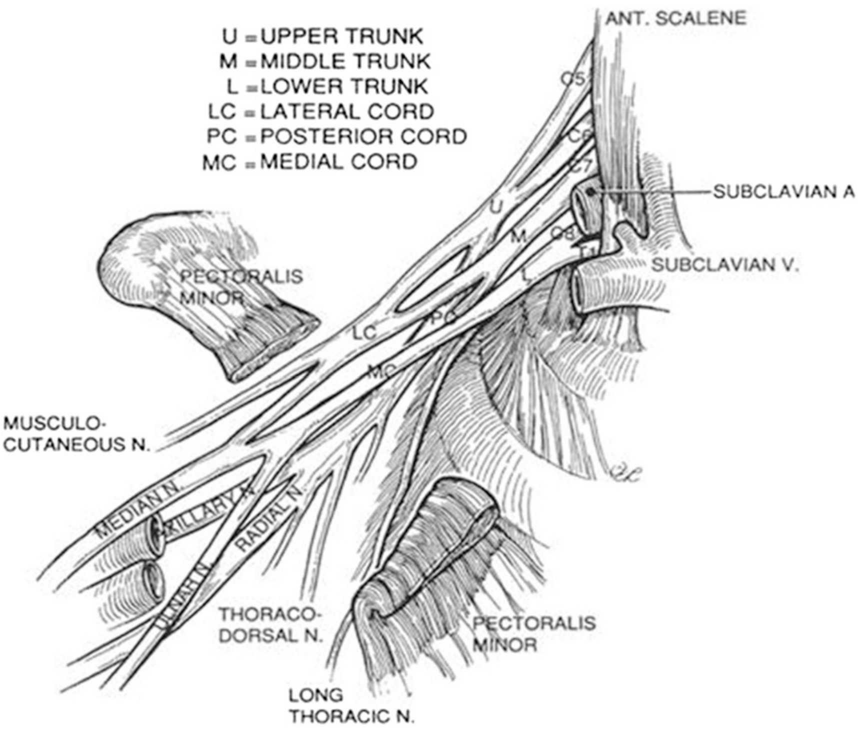

Figure 6. Brachial plexus anatomy. From Sutcliffe TL. Brachial plexus injury in the newborn. *NeoReviews*. 2007;8(6):e239–e246.

Phrenic Nerve Injury

Phrenic nerve injury can be associated with brachial plexus injury. It occurs most often with breech delivery and lateral extension of the neck, with avulsion of C3 through C5 nerve roots. Clinical signs include recurrent episodes of cyanosis followed by respiratory distress. Phrenic nerve injury impairs diaphragmatic excursion on the involved side, resulting in ineffective respiration. Bulging of the abdomen does not occur with inspiration. Diagnosis is made by a chest radiograph showing elevation of the diaphragm in an infant who has an associated brachial plexus injury. A dynamic ultrasonographic study of diaphragmatic excursion may also be helpful. Treatment is close observation in hopes of recovery for 30 days, after which surgical plication or diaphragmatic pacing may be pursued.

Figure 7. Newborn with classic left-sided upper brachial plexus lesion examination findings. From Sutliffe TL. Brachial plexus injury in the newborn. *NeoReviews* 2007;8(6):e239–e246.

FRACTURES

Clavicle Fracture

This is the most common fracture in newborns, with an incidence of approximately 1% to 1.5% from birth trauma. The risk factors for clavicle fracture are use of vacuum and forceps, shoulder dystocia, higher birthweight, and increased maternal age. The diagnosis is based on a displaced fracture in the newborn period; it is often associated with tactile crepitus or petechiae over the affected side. If the fracture is nondisplaced, the diagnosis may be made weeks later by the discovery of a palpable callus. No specific treatment is necessary. Infants may experience increased pain on the affected side for 5 to 7 days. This pain is usually amenable to oral or rectal acetaminophen. Once the callus forms (usually by 7 to 10 days), the pain subsides. Prognosis is excellent without any long-term sequelae.

Skull Fracture

There are 2 types of skull fractures: linear (Fig 8) and depressed (Fig 9). Linear fractures are nondepressed and usually need only close follow-up evaluation and monitoring. Depressed skull fractures have an incidence of 3.4 per 100,000 births. A depressed fracture increases the possibility of an intracranial process, especially when the fracture is greater than 1 cm. Forceps (especially crossed shank) delivery is one of the major risk factors. If the fracture is less than 1 cm, depressed, and with no neurodeficit, it can be managed with close monitoring. Further imaging with CT scan is required to determine the presence or absence of intracranial lesions. Neurosurgical consultation should be obtained within 12 to 24 hours of diagnosis for those with evidence of an intracranial process and if the depression is greater than 1 cm. Subdural hematoma is the most common intracranial injury with depressed skull fracture. The use of a vacuum extractor to elevate significant fractures has been reported, but it should not be used routinely until further studies demonstrate that it is a safe, effective method that is easily performed and can be applied for universal use.

INTRAABDOMINAL INJURIES

Birth-related intraabdominal injuries are very infrequent. Liver and spleen injuries have been reported in the literature. Maternal trauma 1 to 2 weeks before delivery and trauma during the delivery process have been reported to be the major causes of intraabdominal injuries. Liver fracture is more common than splenic injuries. The most common presentation is shock, pallor, anemia, and abdominal distension. Ultrasonography and CT scan of the abdomen are the preferred diagnostic modalities. Treatment involves fluid resuscitation, blood component therapy that includes packed red blood cell transfusion, and clotting factor replacement. Surgery may be needed in extreme situations.

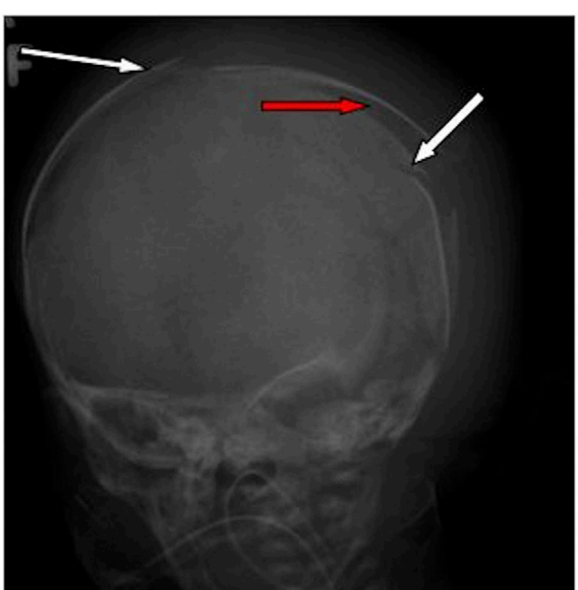

Figure 8. Skull radiograph with comminuted displaced fractures of left parietal and frontal bones (white arrows), mild depression of vertex, and subdural hemorrhage (red arrow). From Mouhayar J, Charafeddine L. Index of suspicion in the nursery. Head swelling and decreased activity in a 2-day-old term infant. *NeoReviews*. 2012;13(10):e615–e617.

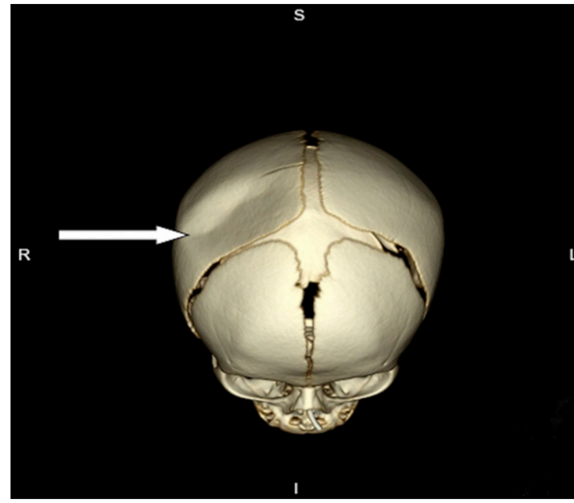

Figure 9. Depressed skull fracture. Several hours after birth, clinicians noted a depressed skull fracture (arrow) in an infant born at 37 weeks' gestation with a breech presentation that prompted cesarean delivery. He was clinically stable, had no intracranial hemorrhage, and did not require surgical intervention. Three-dimensional reconstruction computed tomography scan courtesy of Children's Mercy Hospital-Kansas City.

LONG BONE FRACTURES

Fractures of long bones such as the humerus or femur are not uncommon. Other than the clavicle, humerus or femur fracture are the most common bony injuries during the birth process. Features of humerus and femur fractures during birth process are listed in Table 3. A radiograph showing mid-diaphyseal fracture of femur is shown in Fig 10.

MEDICOLEGAL CONSIDERATIONS

Even with the best perinatal care, natural labor and birth processes can lead to injuries. Clinicians must document the degree of injuries during the first physical examination because the clinical picture can change rapidly. Documentation should be descriptive and factual, including the involvement of natural or instrumented/operative delivery. Depending upon the type of injury, a neonatologist or other specialist should be consulted if there is uncertainty about the injury or the neonate's clinical condition is deteriorating. Documentation of congenital dermal melanocytosis (slate grey spots, formerly called Mongolian

TABLE 3. **Features of Humerus and Femur Fractures**

FEATURE	HUMERUS FRACTURE	FEMUR FRACTURE
Incidence	0.2 per 1,000 deliveries	0.13 per 1,000 deliveries
Risk factors	Shoulder dystocia, cesarean delivery, macrosomia, breech presentation, low birth weight	Twin pregnancies, breech presentation, prematurity, diffuse osteoporosis
Clinical features	Decreased arm movement, localized crepitus, pain with palpation	Asymptomatic or pain response to handling, "pop" or "snap" on delivery
Diagnostic modality	Radiography	Radiography
Treatment	Immobilization with elbow in 90 degrees	Pavlik harness is an optional treatment in newborns
Prognosis	Outcome is excellent	Outcome is excellent

spots) is especially important because these findings may later be confused with bruising after discharge from the nursery. Retinal hemorrhages, rib fractures, and clavicle fractures can also be confused with nonaccidental trauma after discharge from the hospital.

CONCLUSION

The incidence of birth injuries has dramatically decreased in the last 2 decades. Macrosomia and instrumental deliveries are major risk factors for birth injuries. Subgaleal hemorrhage is an emergency, and close monitoring and aggressive resuscitation are key to management. Forceps use is the most common cause of facial nerve injury and is usually self-limited. Erb palsy is the most common brachial plexus injury, and management should include close follow-up evaluation and physical therapy until 3 to 4 months of age. Shoulder dystocia is a major risk factor for brachial plexus injury. Management of clavicle and most skull, humerus, and femur fractures is nonoperative if there is monitoring and timely follow-up. Planned cesarean delivery for breech presentation decreases mortality and morbidity. Posterior fossa hematoma can cause brain stem compression, leading to respiratory compromise, and requires close monitoring. Careful documentation and cooperation between the obstetric and pediatric clinicians in explaining birth injury to parents may minimize litigation.

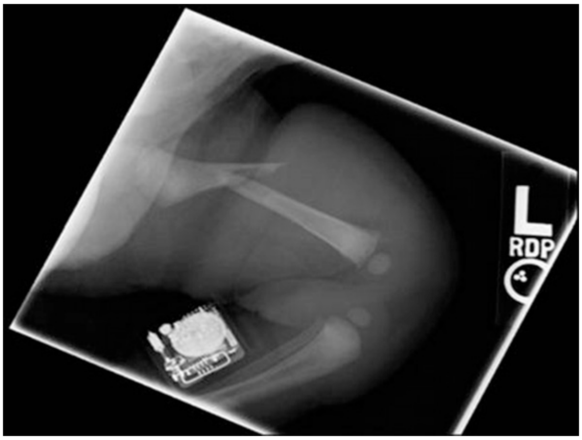

Figure 10. Radiograph showing a mid-diaphyseal oblique fracture of the left femur. From Forneret Denianke B, Chong Lee H. Index of suspicion in the nursery. A nurse notes bilateral swollen thighs in a neonate. *NeoReviews.* 2009;10(12):e613–e615.

Summary

- On the basis of observational studies, the incidence of birth injuries has dramatically decreased in the last 2 decades. (6)(7)(8)
- On the basis of strong evidence and a retrospective cohort, macrosomia and instrumental deliveries are major risk factors for birth injuries. (1)(9)
- On the basis of expert opinion and case studies, subgaleal hemorrhage is an emergency, and close monitoring and aggressive resuscitation are key. (4)
- On the basis of a retrospective cohort, forceps delivery is the most common cause of facial nerve injury and is usually a self-limited condition. (1)
- On the basis of expert opinion and case studies, Erb palsy is the most common brachial plexus injury and management is conservative until 3 to 4 months of age. (5)
- On the basis of expert opinion and case studies, shoulder dystocia is a major risk factor for brachial plexus injury. (10)
- On the basis of expert opinion and case studies, management of the clavicle, skull (unless a neurodeficit is present), humerus, and femur fractures is close observation. (11)(12)
- On the basis of a retrospective cohort, planned cesarean delivery for breech presentation decreases mortality and morbidity. (2)
- On the basis of expert opinion and case studies, posterior fossa subdural hematoma can cause brain stem compression leading to respiratory compromise and needs close monitoring (12)(13)

References and Suggested Readings for this article are at http://pedsinreview.aappublications.org/content/37/11/451.

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1. You are counseling a mother who is 34 weeks pregnant in your clinic. She takes insulin for gestational diabetes yet still has poor control of her blood glucose. She has been told by her obstetrician that her infant is larger than her reported dates and has a breech presentation. Which of the following statements do you report to the mother during counseling?
   - A. Cesarean deliveries present a higher risk for birth injury than vaginal delivery.
   - B. Forceps-assisted deliveries result in a lower risk of cephalohematoma than vacuum-assisted deliveries.
   - C. The degree of risk associated with macrosomic infants remains the same regardless of fetal weight.
   - D. The possibility of a birth injury in macrosomic infants often depends on the mode of delivery.
   - E. Vaginal delivery has the lowest risk of birth injuries for both macrosomic infants and infants with breech presentation compared with caesarian delivery.
2. You are called to evaluate an infant in the newborn nursery. The nurses are concerned about a hard cutaneous area palpated on the left arm shortly after admission. The infant is otherwise well with normal vital signs. Physical examination reveals a small, well-circumscribed area on the left upper arm that is bluish in appearance. You diagnose subcutaneous fat necrosis and quiz the resident in the nursery regarding the cause and prognosis of the lesion. Which of the following best describes subcutaneous fat necrosis in a newborn infant?
   - A. It is very common among preterm infants because of their thin epidermis.
   - B. It has been postulated to increase calcium absorption from the intestine.
   - C. It often results in serum hypocalcemia by unknown mechanisms.
   - D. It requires follow-up monitoring for 6 weeks for possible electrolyte abnormalities.
   - E. It typically resolves spontaneously by 5 days of age.
3. During morning rounds in the nursery, a tearful mother requests that you examine her infant's head for "swelling." She asserts that the swelling was not present immediately after delivery, but now at 24 hours of age it has appeared. You assess the swelling to be a cephalohematoma. Which of the following characterizes cephalohematomas?
   - A. They are largest on postnatal day 5.
   - B. They frequently are associated with a bluish discoloration of the overlying skin.
   - C. They may calcify, with a resulting nodule that does not resolve for 3 to 4 months.
   - D. They may infrequently become infected, causing osteomyelitis, with the most common pathogen being *Staphylococcus aureus* from skin flora.
   - E. They occur in 5% to 10% of all deliveries.
4. An infant is admitted to the NICU following a vacuum-assisted vaginal delivery that involved multiple unsuccessful vacuum attempts. On physical examination, the infant's head is boggy over the occipital region and the infant is extremely irritable to palpation of this area. The residents have gathered around the bedside to observe the infant. One asks the difference between a caput succedaneum and a subgaleal hemorrhage. Which of the following best describes the difference between the 2 conditions?
   - A. A subgaleal hemorrhage may result in sequestering of blood between the epicranial aponeurosis and the dura.
   - B. The bleeding that occurs in a subgaleal hemorrhage is confined in the skull by the orbital ridges, the temporal fascia, and the nape of the neck.
   - C. The classic triad of a subgaleal hemorrhage includes tachycardia, disseminated intravascular coagulation, and increasing occipital frontal circumference (OFC).
   - D. The OFC may increase during a subgaleal hemorrhage by 1 cm for every 100 mL of blood sequestered in the subgaleal space.

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E. Subgaleal hemorrhage frequently results in brain compression requiring surgical evacuation of the hematoma.

5. During rounds in the newborn nursery, you evaluate a 4.8-kg male infant who sustained a brachial plexus injury during a difficult vaginal delivery requiring the use of forceps the prior evening. He has no respiratory symptoms and is feeding adequately. Which of the following is accurate regarding brachial plexus injuries in newborns?

    A. Brachial plexus injuries result from injury to any of the cervical nerve roots (C5-C8).
    B. Horner syndrome is characterized by mydriasis, ptosis, and damage to the sympathetic outflow.
    C. Infants who have Erb palsy experience arm abduction and internal rotation, full extension of the elbow, and flexion at the wrist.
    D. The presence of the infant's grasp reflex distinguishes Erb palsy and rules out total arm paralysis.
    E. Once diagnosed, brachial plexus injuries should be treated with physical therapy weekly and if there is no improvement within 3 weeks, surgical repair should be considered.