J Perinat Neonat Nurs
Vol. 22, No. 1, pp. 60–67

Classification of Major Newborn Birth Injuries

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A classification system of various forms of major newborn birth injuries is clearly lacking in the literature. Currently, no scales exist for distinguishing degrees, extent, or distinctions of major birth injuries. The purpose of this study was to use published and online literature to explore the timing, prediction, and outcomes of major newborn birth injuries. Potential antecedents and causes were used in depicting what were reported to be major birth injuries. The outcome of this literature search was the development of a classification table synthesizing the most frequently reported ($n = 20$) major newborn birth injuries. This classification was developed according to (1) types of tissue involved in the primary injury, (2) how and when the injury occurred, and (3) the relationship of the injury to birth outcomes. A classification scheme is critically needed as the first step to achieving preventive interventions and plans for long-term recovery from birth injuries. Because major birth trauma contributes to increased neonatal morbidity and mortality, its occurrence requires careful study and preventive efforts to better promote newborn health. **Key words:** *birth injuries*, *deliveries*, *malpositioning.*

Childbirth is a complex event. With the involvement of so many potential variables that can complicate the birthing event, it is noteworthy that giving birth takes place as smoothly as it does in the majority of pregnant women. Although birth injuries account for lesser than 2% of neonatal deaths,[1] injuries still occur occasionally and unavoidably, with an average of 6 to 8 injuries per 1000 live births, depending on risk factors (eg, birth weight 4500 g or above), population sampled, and the country of the delivery.[2–4] Presently, there are no dedicated textbooks or "classic textbook cases" of how birth injuries occur, even though causes of injuries commonly involve compression or traction to some degree.[3] Currently, the birth injury references available are book chapters and journal articles in which birth injuries are described and sometimes presented with photographs of the injuries. Obstetrical caregivers, the persons most knowledgeable about birth injuries (obstetricians and midwives), run the risk of having malpractice attorneys use such references in developing litigations involving birth-injured newborns.

The purpose of this study is to present a comprehensive literature review of major neonatal birth injuries. Twenty of the most frequently reported major injuries were classified (Table 1) according to the type of injury, occurrence, and subsequent outcomes. This classification table is the first strategic step toward the future development of a taxonomy of birth injuries. A taxonomy can be a valuable tool to help obstetrical caregivers predict and/or prevent the occurrence or severity of birth injuries and thus improve the long-term outcomes.

Factors responsible for mechanical injury can coexist with hypoxic-ischemic insults, with one predisposing the fetus to the other. Lesions that are predominantly categorized as hypoxic in origin as well as transient injuries are not discussed in this article.

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Submitted for publication: September 6, 2007
Accepted for publication: November 19, 2007

Table 1. Twenty most frequently occurring newborn birth injuries

Specific birth injury[a]	***Type of tissue(s) involved in primary injury***	***How and when occurs***	***Outcomes (temporary/ permanent/variable/fatal/ not stated/unknown)***
Hyphema	Blood vessels	Blunt trauma to blood vessels in the iris bleed and leak into the aqueous fluid[5]	Not stated; unknown
Retinal hemorrhage	Blood vessels	Increased pressure on the skull causes blood vessels on the surface of the retina to rupture[6]	24 h to 6 wk; more likely to resolve within 5 d if they are flame shaped and not until 21 d if they are deep hemorrhages[6]
Intracranial hemorrhage	Blood vessel(s) in or outside the brain	A blood vessel in the head ruptured[7]	Variable; depends on type of hemorrhage[7]
Fractured clavicle	Clavicle	Can occur during difficult delivery of the shoulders in a vertex or a breech delivery[8]	Usually heals in 7–10 d; within a few weeks, a hard lump may develop spontaneously where the bone is healing; if newborn is in pain, affected arm should be immobilized, with the arm abducted more than 60°, and the elbow flexed more than 90°[8]
Cerebellar contusion	Cerebellum	Pathogenesis is multifactorial but can be caused by pressure applied to the head and circulatory events related to prematurity[9,10]	Observation; surgical treatment is restricted to large-surface cerebellar hematomas with mass effect[11]; offset not reported
Abducens nerve injury (cranial VI)	Abducens nerve	Increased incidence with delivery using instruments; increased pressure on the cranium causes nerve damage[12]	Apparently transitory, but recovery time is not reported[12]
Skull fracture	Cranium	Direct compression on the skull by the sacral promontory of the mother or from use of a delivery instrument[13]	Linear fractures heal within several months; depressed fracture offset is not stated; poor outcome for occipital osteodiastasis (separation of the squamous and lateral parts of occipital bone)[13]
Phrenic nerve injury (3rd, 4th, and 5th cervical nerves)	Phrenic nerve	Shoulder dystocia with brachial plexus injury[14]	Usually, recovery occurs spontaneously within 1–3 mo; surgical plication of the diaphragm may be indicated in rare situations[14]
Brachial plexus injuries	Peripheral nerve damage to the brachial plexus, a network of lower cervical and upper thoracic spinal nerves supplying the arm, forearm, and hand	One side of the baby's neck is stretched, which can damage the peripheral nerves by stretching or tearing them; shoulder dystocia leads to complications resulting from forcible extraction of the fetus by traction on the shoulder in a breech presentation or from traction and tipping of the head in a shoulder presentation[15,16]	Stretch injuries usually heal within 3 mo; if the nerves are torn but not at the spinal cord, the nerves may recover; Erb's palsy (upper nerve injury) may recover spontaneously without surgery within 3 mo or up to 24 mo; tear injuries may not resolve on their own; if nerves rupture from the spinal cord, surgical intervention before 12 mo may be required; can take several months or years for nerves repaired at the neck to restore normal function of the muscles of the lower arm and hand; the true rate of full recovery from brachial plexus injuries remains controversial[15,16]

(continues)

Table 1. Twenty most frequently occurring newborn birth injuries *(Continued)*

Specific birth injury[a]	*Type of tissue(s) involved in primary injury*	*How and when occurs*	*Outcomes (temporary/ permanent/variable/fatal/ not stated/unknown)*
Fractured femur	Femur	Usually occurs during a difficult breech delivery when traction is applied to extract fetus[17]	Requires Bryant's traction for 3 wk to resolve[17]
Fractured humerus	Humerus	Usually occurs during difficulty in delivery of the shoulder in vertex presentations and of the extended arms in breech deliveries[18]	Following immobilization using a cast or by strapping affected arm to the chest using a splint, callus development will be seen in 7 d with full recovery in 2 to 4 wk[18]
Facial palsy (cranial nerve VII)	Facial nerve	Pressure on the face from the mother's sacral prominence or an instrument may injure the facial nerve[19]	Variable; after fibrillation, potentials will be seen on EnoG at 10–14 d; function is recovered after a few weeks in most cases; the paralysis can be permanent[19]
Nasal septum deviation	Nasal septum	Primarily associated with vertex deliveries[20]; when the amount of force applied to the nasal cartilage exceeds its biomechanical stress point, the cartilage fractures[21]	Treated with closed surgical reduction within first 3 d postnatally; deviation is permanent unless patient undergoes resection of cartilage and bone[22,23]
Laryngeal nerve injury	The 2 (left and right) laryngeal nerves are attached to the voice box so both can be affected	Results from an intrauterine posture in which the head is rotated and flexed laterally injuring the nerve[24]	4–6 wk, or recovery can take as long as 6–12 mo in severe cases; injury to both laryngeal nerves will lead to obstruction of breathing and the need for a tracheotomy[24]
Ruptured liver	Liver	Compression during descent through the birth canal; associated with difficult and breech deliveries; liver lacerations often caused by abnormal pull on peritoneal support ligaments or effect of excessive pressure by the costal margin[3]	If not treated as a surgical emergency to stop the bleeding, prognosis is fatal because of circulatory collapse[3]; offset not reported
Subdural hematoma	Within the skull but outside the brain; blood clot from a ruptured blood vessel occurs on the surface of the brain and just below the dura covering the brain	Incidence highest with use of forceps followed by vacuum extraction; can also occur without the use of instruments during a vaginal delivery[25]	If hematoma is small, it will disappear on its own within 4 wk[25]; if large, condition can be fatal unless a craniotomy and evacuation of the acute hematoma is completed[26]
Subluxation of cervical spine	Cervical vertebrae, C1 to C7—C1 and 2: head and neck C3: diaphragm C4: upper body muscles (eg, deltoids, biceps, etc) C5: wrist extensors C6: wrist extensors C7: triceps C8: hands	Difficult deliveries involving shoulder dystocia or difficult presentations; longitudinal stretching with lateral flexion or torsion[26]	Minimal long-term or transitory deficits; sponge immobilization of neck can aid recovery; for some major deficits, tetraparesis with respiratory failure and death[26]
Subgaleal hemorrhage	An extra-cranial hemorrhage; blood vessels rupture beneath epicranial aponeurosis; may extend to orbits and nape of neck	Rupture of the emissary veins, connections between the dural sinuses and the scalp veins; blood accumulates between the epicranial aponeurosis of the scalp and periosteum[27]; most often associated with instrumental delivery—either vacuum extraction or forceps but can occur spontaneously[28]	Progressive after birth; after administration of large quantities of blood products will resolve within 2–3 wk;[28] can be fatal if left untreated[27]

(continues)

Table 1. Twenty most frequently occurring newborn birth injuries *(Continued)*

Specific birth injury[a]	*Type of tissue(s) involved in primary injury*	*How and when occurs*	*Outcomes (temporary/ permanent/variable/fatal/ not stated/unknown)*
Epiphyseal separation	Any joint	Upper femoral epiphysis can become dislocated version or breech extraction; the affected extremity shows swelling, slight shortening; limitation of active motion, painful passive motion, and external rotation[29]	Early diagnosis and prompt treatment by anatomic reduction of the displaced epiphysis[29]; recovery times are not reported
Spinal cord injury	Variable degrees of spinal cord disruption, often with hemorrhage	Cause is traction force; usually occurs in cases involving shoulder dystocia and in breech deliveries after excess longitudinal traction to the spine; can also follow hyperextension of the fetal neck in utero; usually affects lower cervical region (C5–C7); when injury is higher, lesions are usually fatal because respiration is completely compromised[30,31]	Milder degrees of injury might improve, but severe injury is irreversible[30,32]; injuries above C4 paralyze the diaphragm and require life-long ventilator support[7,31]; poor mobility is found when focal cord narrowing is seen on magnetic resonance imaging[33]; the best prognostic index is resumption of breathing, particularly on the first postnatal day,[17,34] and recovery of limb motoric functioning during the first 3 mo[35,36]

[a]Injuries are listed by frequency of occurrence reported in the literature, from most common to least common.

OVERVIEW OF BIRTH INJURIES

Birth injuries are defined as a result of, and/or in relationship to labor, delivery, or both.[37,38] Some obvious neonatal signs that have been listed in medical texts as suggestive of birth trauma include injuries to soft tissues (eg, ecchymoses and lacerations),[39] heightened irritability (eg, tremulousness and seizure activity),[37] absent or asymmetrical Moro reflex, diminished or absent limb movement, limb deformity, facial muscle asymmetry, dyspnea, pallor, abdominal distention, and generalized hypotonia.[38,40] Pathology underlying such signs can include multiple entities (eg, different types of cranial nerve injury) and combinations thereof (eg, a newborn with a fractured humerus would elicit an asymmetrical Moro as would a newborn experiencing Erb's palsy).[39] Now that forceps are used less frequently (eg, especially use of mid- and high forceps), many of the injuries that were common before 1966 (eg, skull fractures, facial bone fractures,[1] femur fractures, facial palsy, and cervical spine injuries)[38,41] are rarely seen in the United States today. Breech deliveries are less likely to be completed vaginally, and cesarean deliveries can be performed using a transverse incision instead of a midline incision approach.

The occurrence of major birth injuries can also involve minor transient mechanical birth trauma (TMBT) encountered during the process of birth.[42] For example, a newborn presenting with a skull fracture may also have a cephalhematoma and molding, which are TMBT injuries. But TMBT may go unrecognized when major birth injuries occur because major injuries overshadow seemingly harmless events that have occurred to newborns. The incidence of brachial plexus injury found in the literature was 0.15% to 1.1%.[43–47] The incidence of injuries to the brachial plexus nerve roots (C5–C8 and T1) and indications for surgical repair have increased during recent years.[48] No morbidity statistics were found in either US or international literature for the subheading of major birth injuries; instead, statistics are reported for specific injuries. The 3 most prevalent newborn birth injuries that were published in the literature were hyphemas (blunt trauma to blood vessels in the eye, 12%), retinal hemorrhages (which can be severe, 9%),[49] and intracranial hemorrhages (7.1%).

THE BIRTH PROCESS

The normal birth process comprises a combination of mechanical forces that blend compression,

contractions, torques (different angles), and traction. Even under natural and controlled conditions, the birth process has the potential for involving trauma.[50] When fetal presentation, fetal size, or neurologic immaturity complicates the birth process, intrapartum forces can lead to edema, hemorrhage, tissue damage, fracture, or death in a newborn. Birth injuries fall into 2 major categories: injuries produced by the normal forces of labor and those produced by obstetric intervention.[51] Although many paths are possible, frequently traumatic birth results from the fetus being placed in longitudinal traction combined with hyperflexion and/or hyperextension and rotation along the vertebral axis.[52] Typically, it is larger fetuses, especially those who weigh more than 4500 g and who are more susceptible to birth injuries.[53]

Because of the compression, contractions, torques, and traction that the fetus undergoes in descending through the birth canal, all tissues in the human body are potentially susceptible to injury. Blood vessels, bones, major organs, cranial nerves, peripheral nerves, joints, muscles, the adrenal glands, and eyes can all be involved in major birth injuries.[54] When blood vessels hemorrhage, major organs rupture, bones fracture, and nerves are damaged, other body tissues can sustain additional damage.[55]

THE SEVERITY OF BIRTH INJURIES

Only two thirds of major birth injuries (eg, such as fractured clavicle and fractured femur) are self-limiting and usually have favorable outcomes.[56] Nearly half of major birth injuries and serious negative outcomes are potentially avoidable with early detection and intervention.[57] The ability to decrease birth injuries partly reflects the technologic advancements (ultrasonography and fetal monitoring) that allow obstetricians and midwives to recognize perinatal risk factors for birth injury before attempting a vaginal delivery. Furthermore, the use of the "external version procedure" to change the fetal lie and fetal presentation, as well as the use of more aggressive instrumental techniques, such as a midforceps rotation, has declined during the past decade in favor of cesarean delivery. Yet even cesarean deliveries do not provide total protection against birth injuries (eg, shoulder dystocia injuries). An infant's outcome is the product of multiple variables and events. Some examples of perinatal risk factors that have been linked with birth injuries include large-for-date fetuses, especially fetuses who weigh more than 4500 g, deliveries requiring forceps or vacuum extractors, vaginal breech delivery, and deliveries that require abnormal or excessive traction during the birthing process.[58] Separating the effects of a fetus' hypoxic-ischemic insult from those of a traumatic birth injury is difficult and frequently impossible.

HOW AND WHEN BIRTH INJURIES OCCUR

Typically, birth injuries occur during the second stage of labor, when the fetus is descending through the birth canal.[41] The use of obstetric instrumental techniques, as discussed above, may further amplify the effects of descent but may also induce injury. Furthermore, 12 factors documented to predispose a fetus to birth injury include (1) maternal age less than 16 or greater than 35; (2) primagravida; (3) cephalopelvic disproportion, small maternal stature, and maternal pelvic abnormalities; (4) prolonged or rapid labor; (5) deep transverse arrest of descent of presenting part of the fetus oligohydramnios; (6) abnormal presentation; (7) use of midcavity forceps or vacuum extraction; (8) very low-birth-weight infant; (9) extreme prematurity; (10) large fetal head (eg, hydrocephalus); (11) fetal anomalies; and (12) fetal weight of 4500 g for infants of mothers with diabetes and 5000 g for infants of mothers without diabetes.[41,54,58]

PREDICTING MAJOR NEWBORN BIRTH INJURIES

Birth injury to the fetus is known to significantly contribute to increased neonatal morbidity and mortality.[1] To avoid specific negative outcomes, various evaluative techniques, such as perinatal history, physical examination, radiographs, paracentesis, ultrasonography, computerized tomography scans, and magnetic resonance imaging, can be used to predict more accurately the abnormalities that place the fetus at high risk for major birth injuries. However, predicting the likelihood of an injury's occurrence does not guarantee that it will not happen, but instead may help lessen the severity of the injury.[5]

Developing a taxonomy of birth injuries that can occur would also add to approaches that may be used for different circumstances. No formal professional or research instruments were found in the literature for documenting or evaluating the degree of trauma resulting from birth injuries. Other than Volpe's classification of neurologic birth injuries affecting the cranium, central nervous system, and peripheral nerves,[38] the only scale found for evaluating the amount of birth trauma was a summative one for minor TMBT.[42] Furthermore, no scales were found in the literature for grading degrees, extent, or distinctions of major forms of birth trauma. Primarily, birth injury is characterized as a nominal

variable in terms of it being present or absent. To better understand how to proceed cautiously with predicting newborn birth injury, specific information pertaining to the onset, diagnosis, and offset of birth injuries should be of critical concern to physicians, nurse midwives, and nurse practitioners.

REPORTS OF MAJOR INJURIES

In this article, birth injury was distinguished as "major" if it had the potential to produce negative neonatal outcomes leading to long-term difficulties, disablement, or illness. Table 1 presents a classification of 20 of the most frequent major birth injuries reported in the literature.

On the basis of frequencies alone, some of the major findings that can be seen in Table 1 can be highlighted. For example, 8 (40%) of the injuries involve blood vessels and some type of hemorrhage. Nerves or the nervous system is involved in 6 (30%) of the injuries, and a major organ is also involved in 6 (30%) of the injuries. Only 5 (24%) of the injuries are the result of some type of bone fracture. The cause of injuries is thought to be associated with the occurrence of shoulder dystocia in 6 (30%) of the cases. Use of instrumental techniques (eg, forceps or vacuum extractors) is stated as being involved in at least 11 (55%) of the injuries. Six (30%) of the birth injuries were reported as leading to a potentially fatal prognosis. The offset of the injuries was not reported in the literature for 6 (30%) injuries.

This review of the 20 most frequently occurring major birth injuries has important implications for designing research studies and identifying predictors of birth injury. It is crucial to be able to identify factors that may interfere with the occurrence of a difficult delivery as well as those that may trigger more severe trauma causing injury during delivery. Evidence from this type of research would help caregivers identify risk factors in exploring the incidence and intensity of major newborn birth injuries, particularly the relationship of fetal macrosomia to injuries, and will be a critical step in developing preventive approaches.

Furthermore, beginning to elucidate a taxonomic structure of birth injuries could be the next step in designing research for birth injury identification. To say that the prevention of fetal macrosomia, judicious use of vacuum extractors, and greater attention to the course of labor are the answers to preventing major birth injuries is overly simplistic and misleading. What stands out in the literature and in practice is that a coherent system for recording and classifying birth injuries is needed. There has been 1 attempt to classify transient birth injuries using indices of mechanical trauma and 1 attempt to classify major birth injuries by whether or not they affected the cranium, central nervous system, or peripheral nerves.[39] A more comprehensive birth injury classification scheme that incorporates tissue types (eg, bone, nerve, muscle, vasculature, etc.), effectiveness of treatments, and recovery times from birth injuries might stimulate healthcare providers to also look for more comprehensive preventive interventions for birth injuries.

In conclusion, as emphasized throughout this article, a comprehensive classification system of major newborn birth injuries is seriously lacking in the literature. Currently, no scales exist for distinguishing major birth injuries in terms of degree, extent, or distinctions. What is needed is the design of research aimed at developing a taxonomy of birth injuries. A taxonomy of birth injuries has potential utility to inform neonatal nursing practice and policy about opportunities and resources needed to achieve desired outcomes for neonates delivered vaginally or by cesarean birth (Table 1).

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