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Chapter

Neonatal Fractures

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Abstract

A neonatal fracture is a severe complication creating problems regarding diagnosis and appropriate management. Diagnosis from the neonatologist occasionally is difficult. A paediatric orthopaedic surgeon is required to evaluate the neonate, and confirm diagnosis and treatment. Clavicle fracture is the most common injury that must be differentiated occasionally from neonatal brachial plexus palsy. The clinical signs are crepitus, swelling, bony prominence, with the restriction of the movements of the arm. Occasionally, the fracture is diagnosed later. Clavicle pseudoarthrosis is a rare dysplasia. Fracture of the femur or the humerus presents with swelling, crepitus and deformity of the limb, creating difficulties in clothing, bathing and feeding. Most commonly are found in urgent caesarean delivery or complicated dystocia with over-weighted neonates. Bone fragility diseases (osteogenesis imperfecta, hypophosphatasia, arthrogryposis) are diagnosed from neonatal fractures. Conservative treatment with immobilization is the method of choice. Extremely rare is surgical treatment. Premature and low-weighted babies are in high risk to sustain fractures. Epiphyseal fractures of the distal femoral or humeral epiphysis are rare fractures, difficult to be diagnosed initially. They require immediate reduction to avoid permanent lesion of the growth plate. Fractures of forearm, tibia or vertebrae are extremely rare and associated with a bone fragility disease.

Keywords: neonatal fracture, perinatal femoral fracture, perinatal humerus fracture, fragile neonate bone, premature and low weight neonates, birth related fractures

1. Introduction

Neonatal fractures are extremely rare. Initial diagnosis is occasionally obscure and clinical signs of oedema, crepitus, and mainly discomfort of the neonate are the main symptoms that the neonatologist is evaluating. The incidence of neonatal fractures is reported to be less than 1 per 1000 births. In a previous report among 158,035 full term neonates, fracture was demonstrated in 1174 of them (0.74%). In a recent survey in UK, in the period 2000–2016, in 87,461 live births, 66 sustained a fracture, with the clavicle fracture being the most common, as found in 46 cases. This is a low incidence overall of 0.075% [1, 2]. Increased fetus weight and vaginal delivery with associated labor dystocia were initially reported as predisposing factors. But several reports of fractures with cesarean delivery (CS) are reported as well. Preterm with small for gestational age babies are in increased risk for a neonatal fracture. Multiple birth, breech delivery, increased maternal body weight are among the risk factors for a neonatal fracture. Neonatal fractures may present as the initial sign of underlying
bone fragility. Neonatal fractures are occasionally diagnosed in uncomplicated labor. A neonatal fracture may also be diagnosed after discharge from the maternity hospital, usually found from the callus formation or the persistent discomfort of the neonate [3–7].

2. Clavicle fractures

Fractures of the clavicle are the most common neonatal fractures. They are usually found in vaginal delivery of an overweight neonate. Shoulder dystocia is a severe complication during birth and immediate action is required from the obstetrician in order to avoid respiratory disturbance of the neonate. The fracture of the clavicle reduces the shoulder tension and promotes the early delivery of the neonate. Otherwise the hyperextension of the neck may lead to severe brachial plexus palsy. A fracture of the clavicle in a neonate can be diagnosed without history of dystocia, most commonly after a cesarean delivery. Urgent cesarean births have a higher incidence of clavicle fractures. Delayed deliveries over 39 weeks of gestation are reported with a higher incidence of clavicle fracture and brachial plexus palsy [8–14].

The main clinical sign is the restricted Moro reaction sign (Moro (startle) reflex, arms abduct in response to sensation of falling) that is the reduced abduction and external rotation of the affected arm. This is the most common examination test that the neonatologist performs in the newborn. The newborn has active movements of the wrist and fingers and easy flexion of the elbow in the affected side. The newborn expresses discomfort and is crying while changing clothes or while moving the arm while breast feeding. Oedema in the clavicle region appears usually in the 2nd and 3rd day, with crepitus while examining the clavicle. The clavicle ossifies following intramembranous and not endochondral ossification. It produces early an enlarged callus that is remodeled and the signs of the clavicle fracture are eliminated by the 3rd month. Clinical signs are often obscure early and the family notices the presence of the enlarged callus in the clavicle region after a week time. There are normal movements of the affected side and even the Moro sign may have been reported as normal.

Radiological examination confirms the diagnosis and is mainly performed for the medico legal issues in case that there are associated lesions as brachial plexus palsy. Radiological examination is not always required since in typical cases we can reassure the parents for the benign course of the clavicle fracture. Ultrasound examination from an experienced radiologist can assist by confirming the disruption of the cortical continuity. There is no specific treatment that is required for this fracture. We inform the nurses and the family for the appropriate dressing and bathing of the neonate and to avoid the elevation of the affected arm. In a few days the neonate is moving the arm without discomfort. The arm is kept in the relaxed position with the elbow in 90 degrees of flexion, in the anterior part of the body (Figures 1 and 2).

The presence of an enlarged lump on the right clavicle of a baby, after several months, must be differentiated from congenital clavicle pseudoarthrosis. This is an extremely rare dysplasia, usually diagnosed in the preschool age, as it is a painless lump in the clavicle. Appropriate imaging with X-ray and CT scan confirms the diagnosis of the congenital pseudoarthrosis. There is absence of history of birth trauma. This dysplasia can be treated surgically with appropriate excision and plating, mainly for esthetic reasons. A new born with bilateral pseudoarthrosis of the clavicle that presented spontaneous recovery has been reported [15, 16] (Figures 3 and 4).
Neonatal Fractures
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Figure 1.
Fracture of left clavicle.

Figure 2.
Unable to perform the Moro reaction with the left arm.

Figure 3.
X-ray-s of bilateral clavicle pseudoarthrosis with spontaneous union at a year time.

Figure 4.
X-ray-s of bilateral clavicle pseudoarthrosis with spontaneous union at a year time.
3. Neonatal femoral fractures

A neonatal femoral fracture is a rare but severe complication of the birth. The reported incidence is about 0.1/10000 births [17]. Although was believed that elective cesarean delivery would eliminate the incidence of birth trauma, this is not confirmed, and several reported neonatal femoral fractures are associated with CS. Femoral fracture in CS is an extremely rare complication. Urgent CS, increased birth weight, breech position, fibromatosis of the uterus, inadequate uterine relaxation, inadequate incision in the uterine segment are reported as predisposing factors for femoral fractures in CS [1–5, 17–21].

The obstetrician may feel the cracking sound and observe the pathological mobility of the femur, but this is uncommon. The examining pediatrician and the nurse will notice the swelling of the fractured femur and the abnormal shape and movements of the leg. The neonate is crying and dressing is extremely painful. Suspicion for the fractured femur may not be noticed until the 2nd and 3rd day of the life. Mother will report the permanent irritation of the neonate, the difficulties for breast feeding, since every movement causes crying. A case of a spiral femur fracture diagnosed 9 days postpartum, after an elective CS for the breech presentation has been reported [22].

Diagnosis is confirmed with appropriate X-ray examination. Fractures commonly affect the proximal third and the diaphysis of the femur. The proximal part is shifted in flexion and abduction, due to the imbalance of the muscle action (Figures 5 and 6).

Treatment is provided with appropriate skin traction, either with Bryant’s traction (both limbs suspended in the air vertically at 90°) or with simple skin traction. We use bilateral traction, with hips flexed in 90° and the buttock in a distance from the bed. We use simple skin traction in fractures in the middle third of the femur. Breast feeding becomes difficult, as the mother must lie in an uncomfortable position and the neonate is trying to feed by flexing the head, while it is in the traction. With patience and assistance from the nurse, this can be achieved. In premature children that must remain incubated or in the box, this traction is applied in their box [23, 24].

Fractures are united with excessive callus formation (Figure 7).

Usually a period of 2–3 weeks in traction is adequate to remove the traction. Use of Pavlik harness has also been recommended, with appropriate balance of the fractured
parts of the femur but is not a stable position mainly during the first week. Use of the harness requires frequent adjustments and the nursing staff is unfamiliar with these corrections. We recommend the use of the harness after at least 10 days of traction,
with caution, since the oversight of a pediatric orthopedic surgeon is of great importance in order to retain the appropriate reduction. Alternative methods of immobilization have been reported. Strapping the thigh to abdomen or the use of a hip spica are also described methods of immobilization [18]. We recommend for the neonate with a fractured femur the use of skin traction with Bryant’s method as the safest and comfortable treatment. We have treated 5 neonates with femoral fractures, using skin traction over the past 20 years and we report very good results. We have not observed any rotational deviations and no leg length discrepancy in the first years of life.

The natural history is the early remodeling of the fracture. The child is observed up the age of 2–3 years old, to ensure the final leg length discrepancy and the appropriate shape of the femur. During the treatment period with skin traction it is of paramount importance to correct possible severe external rotation of the femur, since rotational deformities are not corrected with the remodeling process (Figures 8 and 9).

Surgical treatment is not recommended for the neonatal fracture. A case from Italy was reported using an external fixator for a neonate with lumbar myelomeningocele and fractured femur [25]. In case that fractured parts show severe angulations that must be corrected with appropriate change of the traction. We have treated an extremely rare case of a neonate that the fractured segment was caught under the skin. Despite the use of Bryant’s traction and appropriate manipulation this was not corrected. We performed a minimal skin incision to reduce the fracture by splinting the muscles and stabilized temporally the segments with a K-wire and hip spica.

Figure 8.
Excessive callus formation at 3 weeks of the fractured neonate femur.
The neonate was closely observed with appropriate support from neonatologists. He had an uneventful recovery (Figures 10 and 11).

4. Fragility neonatal fractures

Fractured neonatal femur may be the initial sign of an underlying disease with bone fragility. Osteogenesis imperfecta (OI) is a heterogeneous connective tissue disorder characterized from severe osteoporosis. The synthesis of collagen type I is disrupted due to pathogenic genes. There is low bone mass with bone fragility that leads to recurrent fractures of the axial skeleton and the long bones resulting in severe deformities. Although there have been reported to be more than 20 types of gene
heterogeneity of OI, the clinical phenotype classification of Silence remains a valuable description of the severity of the disorder. The lethal form (type 2) presents with intrauterine fractures diagnosed with the prenatal ultrasonography. Long bones are described with bowing and shortening. X-ray examination in the neonate reveals several fractures, occasionally affecting the ribs as well. Femoral or tibial fractures are either spiral or transverse fractures. Type 3 OI presents with fractures without history of urgent manipulation of the neonate because of dystocia. On x-ray examination the bones are deformed and there is cortical thinning [26, 27, 34] (Figure 12).

With minor handling of the neonate, a crack may be felt and a new fracture may be diagnosed. There are clinical features with the prominent frontal bone, the short height of the neonate, and the ligamentous laxity. Child abuse must be ruled out in the presence of multiple fractures that are at different times of callus formation. Fractures found in clavicles, long bones or vertebrae are strong indications of the underlying

Figure 1. Minimal incision, release of muscles and reduction, stabilized with a K-wire and hip spica. Apparent callus formation in a week time after reduction.

Figure 2. Initial fracture of the left femur, following an uncomplicated normal vaginal delivery. Bowing and sclerosis of the right femur is noticed. The girl was diagnosed with osteogenesis imperfecta type 3.
bone fragility [35]. There are several metabolic diseases affecting the neonate that present with neonatal fractures. Disturbances of the calcium and phosphate metabolism as in phosphatasia and rickets are among the rare but severe diseases that are diagnosed through neonatal fractures, affecting both long bones and vertebrae and ribs. Appropriate laboratory investigations from neonatologists and endocrine pediatricians with genetic investigations, can provide an accurate diagnosis [28–32]. Treatment of neonatal fractures that are due to metabolic diseases follows the same principles as the femoral fractures of normal neonates with the use of Gallows traction. Modifications for use of traction in the neonatal box are described. Appropriate medical treatment is essential in order to reduce the number of fractures that may follow. Gene therapy is today the most promising treatment method for these severe forms. Stem cells therapy in the prenatal period has been reported [33].

Bilateral neonatal femoral fractures have been reported in a neonate with multiple congenital anomalies, with joint stiffness, similar to arthrogryposis. Arthrogryposis may be prenatally detected in a fetus with reduced mobility. It is important for the obstetrician to be informed of the joint stiffness in order to avoid vigorous movements that may lead to neonatal fractures [36] (Figures 13 and 14).

Figure 13. Bilateral fractured femur in a neonate with complex stiff joints. Casts were applied for the club feet deformities. Treatment provided with Gallows traction. X-ray with united femoral fractures.

Figure 14. Bilateral fractured femur in a neonate with complex stiff joints. Casts were applied for the club feet deformities. Treatment provided with Gallows traction. X-ray with united femoral fractures.
5. Metabolic bone disease in premature neonates

Premature neonates apart from the problems of low birth weight and respiratory disturbances, are associated with impaired mineralization of the bones. Several metabolic disturbances that include hypocalcemia, hypophosphatemia, and secondary hyperthyroidism must be ruled out in order to improve bone strength. Spontaneous fractures and deformities may appear and the nursing stuff and neonatologists must be very careful in the daily treatment of these premature neonates [37–42].

6. Distal femoral epiphysis lesion

A rare type of neonatal femoral fracture is the epiphysiolisthesis of the distal femoral epiphysis. The knee joint presents with effusion, there is limited movement of the affected limb, like a type of pseudoparalysis. The neonate is restless and bathing and dressing are difficult because of the reactions of the neonate. Diagnosis is obscure and septic arthritis of the neonate must be differentiated from epiphysiolisthesis. The distal femoral epiphysis ossification nucleus appears in infancy, but it is a small one and separation is not easily apparent on plain X-rays. Plain X-rays may appear with a minimal disruption of the metaphyseal corner. Ultrasound examination is helpful but cannot confirm diagnosis, as the fluid collection of the effusion may be a sign of infection. MRI examination will reveal the translation of the epiphysis. On MRI the hematoma is well demarcated with the separation of the epiphysis in the growth plate (Figures 15–17).

Figure 15.
Distal femoral epiphysiolisthesis Salter type 1, with calcification from the periosteal elevation. MRI demonstrates the hematoma and the periosteal elevation.
Figure 16. Distal femoral epiphysiolisthesis Salter type 1, with calcification from the periosteal elevation. MRI demonstrates the hematoma and the periosteal elevation.

Figure 17. Distal femoral epiphysiolisthesis Salter type 1, with calcification from the periosteal elevation. MRI demonstrates the hematoma and the periosteal elevation.
The distal femoral epiphysis is the most important for the proper growth of the limb, so the lesion must be diagnosed early in order to reduce the epiphysis. It is a Salter Harris type 1 or 2 lesion. The limb is immobilized in a light cast, incorporating the foot. If properly reduced, then growth of the limb may not be affected. The neonate must be followed for the next years to confirm the leg length equality. There have been reported cases with reduction and stabilization using K-wires. These injuries may create severe leg length discrepancy (LLD) and it is important for them to be evaluated by a pediatric orthopedic surgeon [43–48].

7. Humerus fractures

Fractures of the humerus are most commonly found in cases of urgent CS with the inappropriate handling of the fetus in an effort to complete the delivery and ensure proper respiration of the baby. Similar to femoral shaft fractures in the lower extremity, clinical signs are the absence of movement of the arm, angulations, oedema, and crepitus. Because of the decreased musculature of the humerus, this fracture is more easily diagnosed, as during bathing or dressing the neonate, the arm is angulating and the neonate is crying.

X-ray examination reveals the shaft fracture of the humerus (Figures 18 and 19). This must be differentiated from brachial plexus palsy with accurate clinical assessment. Occasionally radial nerve palsy may be found in conjunction with the neonate humerus fracture. Isolated radial nerve palsy has also been encountered in a neonate with a constriction from the umbilicus cord, without underlying fracture. It resolved gradually in a 3 weeks period [49–55] (Figures 19 and 20).

There are various methods for appropriate immobilization of the humerus fracture, but in case of a transverse fracture it is difficult to obtain a stable immobilization. Use of a U slab is uncomfortable and we prefer a Velpeau type of immobilization that is easily accepted and comfortable, enabling the proper breastfeeding of the neonate (Figure 20). It is important to achieve proper rotational alignment of the fracture since remodeling of the rotational deformities is poor. Excessive callus formation is found by the end of the 2nd week, and gradual mobilization is permitted. Humerus fractures may also present as the initial signs of metabolic disease and OI [35] (Figure 21).

Figure 18.
Fracture of the left humerus after an emergency CS delivery.
8. Fracture of the distal humerus epiphysis

An extremely rare injury is the epiphysiolisthesis of the distal humerus epiphysis that is commonly diagnosed with delay. Clinical signs are swelling of the elbow, with increased anxiety of the neonate and reduced mobility of the affected arm. The differential diagnosis includes neonatal septic arthritis and brachial plexus palsy. Appropriate clinical examination is essential for the correct diagnosis. Radiological examination reveals signs of possible elbow dislocation (Figure 22). There is malalignment of the humerus with the proximal part of the radius and ulna. The distal humerus epiphysis is not ossified and cannot be found separated from the metaphysis on X-ray. The medical
history of possible forceful handling of the arm during delivery is of importance. Ultrasound examination is helpful by revealing the diffuse hematoma and the separation of the chondral epiphysis. MRI has been used in order to make the diagnosis. The distal epiphysis appears separated from the metaphysis of the humerus.

Appropriate reduction in the first 2–4 days is essential in order to restore the anatomy and appropriate elbow function. Reduction is easily performed in the first 1–2 days with an impressive resolution of the symptoms. The elbow becomes less swollen and the relief of the neonate appears almost immediately. Proper casting with a brace is important for a period of 2 weeks. Reduction must be performed under anesthesia, using C-arm and possibly with the addition of an arthrogram, in order to

Figure 21. Fracture left humerus, after a CS delivery, as the first sign of Osteogenesis imperfecta.

Figure 22. Distal humerus epiphysiolisthesis appears on X-rays as an elbow dislocation.
reassure the accurate reduction. Arthrogram in the neonate elbow is hard to be achieved with accuracy but in cases of a fracture with the hematoma of the joint that is swollen, it can be performed. Callus formation from the periosteal elevation in neonates is apparent early and reduction is not advised later than a period of a week.

K-wire stabilization is reported in cases of instability of the epiphysiolisthesis, but Salter type 1 and 2 are usually stable after appropriate reduction and cast immobilization is adequate. Remodeling of the humerus has been reported even in cases that the epiphysiolisthesis was diagnosed later and without reduction. But this extremely rare injury must be treated with adequate reduction in the initial first days [56–65].

9. Fractures of forearm

Fracture of the forearm is extremely rare and may be a sign of the underlying bone fragility, with similar fractures in the femur or humerus. Child abuse must be ruled out. Extremely rare is the report of a constriction band in the forearm with fracture of the underlying radius and ulna, with severe compromise of the vascularity of the forearm. Pseudorarthrosis of the radius or ulna as signs of neurofibromatosis are rarely diagnosed in the neonatal period. Hyperostosis of the forearm (Caffey disease) is among the extremely rare cases with x-ray similar to neonatal fracture [66–70] (Figures 23 and 24).

10. Fractures of the tibia

These fractures are also extremely rare and are found in combination with fractures of the femur or humerus. Underlying bone fragility is suspected and investigations for possible OI or rickets must be performed. Neonate abuse syndrome must also be verified. We have followed a neonate that sustained fractures of the femur and tibia during birth after having a normal uncomplicated vaginal delivery. At the age of 2 years there is only short stature, without underlying metabolic disease (Figures 25–27).
Metaphyseal greenstick type of fracture may be found as a result of vigorous handling of the leg of the neonate. They are differentiated from cases of fibrocartilaginous bowing that are usually found during the standing period of the infant. Constriction band syndrome with tibia and fibula fracture has also been reported. Congenital pseudoarthrosis of the tibia or fibula is diagnosed rarely in the neonatal period as part of the neurofibromatosis, presenting with anteromedial bowing. Congenital posterolateral bowing of the leg is a congenital benign deformity that is not correlated with a fracture [35, 66, 71–73].

Figure 24. 
Hyperostosis of the forearm (Caffey disease). Initial X-ray with periosteal reaction and plastic deformation of the radius and ulna on the right side, while the left forearm is normal. The radiological appearance at 1 year, showing widening of the forearm bones.

Figure 25.
Multiple fractures of femur (right with callus formation, spiral left femoral fracture and tibia left). X-rays at birth and at 3 months. At the age of 2 yrs, there are no more fractures reported. The toddler is low height.
Figure 26.
Multiple fractures of femur (right with callus formation, spiral left femoral fracture and tibia left). X-rays at birth and at 3 months. At the age of 2 yrs, there are no more fractures reported. The toddler is low height.

Figure 27.
Multiple fractures of femur (right with callus formation, spiral left femoral fracture and tibia left). X-rays at birth and at 3 months. At the age of 2 yrs, there are no more fractures reported. The toddler is low height.
11. Vertebral fractures

Severe spinal lesions affecting the cervical spine are extremely rare and affecting mainly the spinal cord and not the vertebrae. There are severe lesions associated with paralysis and they are usually lethal. Fractures of the vertebrae are found in neonates in severe lethal cases of OI and phosphatasia [74–77].

12. Conclusion

Neonatal fractures are reported affecting all parts of the skeleton. Their incidence is increased in cases of difficult labor with an overweight neonate. Cesarean delivery in an emergency is associated with higher incidence of long bone fractures. Neonates with an underlying disease with bone fragility sustain neonatal fractures. Fractures may also appear in uncomplicated normal labor.

Clavicle fractures are the most common and their management is appropriate handling of the neonate. Callus formation that is diagnosed later as a prominence in the clavicular area is often the main symptom. Fractures of the femur and humerus are severe complications that require appropriate treatment from a pediatric orthopedic surgeon. Diseases with bone fragility must be ruled out. Premature babies with low birth weight are at increased risk to sustain fractures. Diagnosis of epiphysiopelvis of the distal femur and humerus is extremely difficult and appropriate reduction is essential for the management. Neonatal fractures are complications of the labor that occasionally lead to severe medicolegal problems.

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