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Newborn Neurological Assessment, Basics of Clinical Practices

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

The purpose of a neurological examination of the newborn is to determine a normal neurological condition and to detect abnormal conditions. The examination includes assessment of the central and peripheral nervous system and observation of posture, muscle tone, strength, reflexes and symmetry. Abnormal assessments may indicate neurological problems. As a rule, neurological maturity varies according to gestational age. Systematic physical examinations usually detect neurological defects. Early detection is crucial as plasticity is greater in early life. Despite developments in neuroimaging and neurophysiological technologies, clinical neurological examinations still have their importance. Performing a timely neurological assessment can speed up the diagnostic process and enable the swift administration of advantageous therapies. This is specifically applicable in situations that require therapeutic hypothermia to be initiated within six hours or sooner, as evaluation of neurologic status plays a crucial part in identifying the necessity for intervention. Neurophysiological technologies can be difficult due to immaturity and reduced myelination in neonates. This article aims to provide readers with a better understanding of the few basic concepts of neurological assessment in neonates.

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1. INTRODUCTION

The neurological examination of newborns is informative, cost-effective, and time-saving and helps with early diagnosis and the implementation of therapies. There are many standard neurological objective assessment tests and scales available with good sensitivity and specificity [1]. The neonatal neurological examination is a cornerstone in the assessment of a neonate's neurological function. Compared to other systems, the neurological examination is also simple, and the neurological examination will give more accurate information. Early recognition of abnormal findings is compulsory in some conditions; we should make early decisions, like recognition of subglaleal haemorrhage, differentiation of clavicular injury, and brachial plexus injury. General body movements will detect cerebral palsy with a sensitivity of 97.6%, with a specificity of 95.7%. This will explain how important the neurological examination is [2]. This review aims to present the fundamental principles of neonatal neurology and address prevalent conditions that are frequently disregarded. We discussed important and conceptual aspects of the neurological examination. This is a summary and does not replace a thorough neurological assessment.

History: Birth histories for three generations need to be taken. autosomal recessive disorders will occur through consanguinity. It is better to find the age of the parents, as the father's age is associated with Marfan syndrome, and both parent's ages may increase the incidence of Down syndrome. A history of fever or infection is needed to rule out TORCH infections, and a history of hyperthermia may cause neural tube defects. It is also advisable to ask about any other routine history regarding Tetanus immunization, iron, and folic acid intake. A history of tetanus toxoid may be useful in the differential diagnosis of Hyperekplexia even though neonatal tetanus is eliminated. Periconceptual folic acid is important as the neural tube forms during the early days.It is best to ask for a polyhydramnios history, as it is observed in some neurological cases like Neural Tube Defects(NTD) and Spinal Muscular Atrophy (SMA). Polyhydramnios and intrauterine growth restriction (IUGR) may be associated with a baby's genetic problems. Also, IUGR and oligohydramnios indicate fetal distress or placental problems. Therefore, it is preferable to ask about the fetal movements. It is also better to ask for exposure to radiation and drugs in the first trimester. In addition, a delay in labour may indicate anencephaly. Early antenatal scans may be useful for neural tube defects such as the lemon and banana signs. Enlarged cisterna magna may be associated with autism, and we can diagnose early hydrocephalus through ultrasound.

The timing of the initiation of oral feeding and breastfeeding usually tells us about a history of asphyxia. Some babies may cry excessively in cases of asphyxia. It is better to know the cause of asphyxia, whether it is an acute event like uterine rupture or cord prolapse or a chronic event like the cord around the neck. If acute events cause basal ganglia injury, the baby's tone is normal despite severe asphyxia. In these cases, the brainstem is usually involved, leading to swallowing problems and irregular respiration. In chronic cord entailment conditions, parasagittal injury, which is a watershed area in terms of babies, will occur; in severe cases, the flexion tone of the upper limbs will decrease [3].

General Examination: The general examination will start from head to toe. White, bland colour; babies may have phenylketonuria or albinism. A type of phenylketonuria may mimic cerebral palsy. The diamond-shaped anterior fontanel at the junction of the coronal and sagittal sutures measures 1–4 cm in a full-term neonate. The triangular-shaped posterior fontanel, located at the junction of the lambdoidal and sagittal sutures, is small, admitting only the tip of a finger. We should measure the diagonal because we can't measure in a straight line. Enlarged squamopetrosal sutures indicate an early sign of hydrocephalus. The fontanelle should be checked from posterior to anterior; check for the absence of pulsations, which indicate raised Intracranial pressure. Head circumference measurements usually take three times the average by the overlapping method. Babies born to insulin-dependent diabetic mothers typically have a low head circumference. Enlarged head circumference is usually a late sign of hydrocephalus, as in neonates with a lack of myelin and increased water content, the white matter becomes very thinned by CSF pressure before the increase in head circumference [4]. Caput is usually firm in consistency, but usually, we see some minimum fluid consistency because of an underlying subgaleal hematoma.

Subgalial hematoma, a usually dangerous condition, can accumulate in the whole blood of the baby. Each centimetre increase in head circumference will accumulate 40 ml of blood, which is why continuous monitoring is needed [5]. Sometimes, subgaleal haemorrhage becomes hard because of the organization of the blood. That is why it is preferable to see the nape of the neck and protruding ears. Cephalohematoma appears after the 2nd and 3rd days after Caput's disappearance. Since it's usually hard and bilateral because of the pressure of the iliac bone, it will cause prolonged jaundice.

All term babies will have tremors on the tongue, but it is better to differentiate them from fasciculation, which, though rare, will disappear with the movement of the tongue. Arthrogryposis, a high-arched palate, overriding sutures, and a cortical thumb indicate intrauterine asphyxia [6]. More than two whorls are in the head, and there is a chance of parenchyma problems. Occipital hair will usually be in the telogen phase; that is why it is usually lost in the cerebral palsy child. A cleft palate and any central body lesions indicate pituitary abnormalities. In pituitary abnormalities, growth is usually normal. It is better mentioned here. A low chin may be the first sign of the Pierre-Robenson sequence; always look for a U-shaped cleft palate. While esotropia and exotropia are normal, horizontal eye deviation usually indicates seizures.

Decreased Palmar-plantar creases are usually due to immobility of the baby except for the vertical one between the great toe and 2nd finger. It formed due to the folding of the foot. The semian crease also indicates hypotonia. A capillary haemorrhage in the face is better to follow as symptoms of neurological involvement occur later. Flexion of the big toe also indicates stress. In hypotonic babies, the lateral aspects of the thigh also touch the ground. A straight umbilical cord may indicate asphyxia, stillbirth, and spinal muscular atrophy. Check for neurocutaneous markers. It is always better to observe the movement of the shoulder joints as they indicate diaphragm maturity as both are supplied by C5. Open or closed mouth and lower diaphragmatic retractions indicate the integrity and development of the nervous system. If an open mouth is usually present in preterm neonates, as the tone will progress from caudo cephalic, a closed mouth will indicate readiness for paladai feeding. Proximal extremity weakness is common in congenital myopathies, Undescended testis may be a sign of SMA. Any extremely preterm babies' open eyes may indicate intraventricular haemorrhage, but nowadays, after antenatal steroids, we do not see them commonly. Irregular respirations with limb palsy usually indicate diaphragmatic palsy. If the sacral dimple is more than 2 mm in diameter and 5 cm away from the anus, it is better to rule out spinal neurological problems.

Gestational Age Assessment: Gestational age assessments can be done through foot length, the vascularity of the anterior lens, the last menstrual period, and the Ballard score. While first-trimester ultrasonography is considered more precise for estimating gestational age, Ballard scoring can still provide reliable results within a range of plus or minus 2 weeks. The Ballard score assesses passive tone, as active tone may vary depending on the baby's state; flexion tone will increase in the caudocephalic direction. Typically, at around 32 weeks, lower limb flexion will be observed, while upper limb flexion increases to about 34 weeks. A Ballard score assessment can be performed up to seven days after birth. Physical and neurological scores are being factored together in compensation for each other. Insulin-dependent diabetic mothers' babies are likely to have greater physical growth than neurological maturity, while intrauterine growth-restricted babies could show reduced physical maturity but enhanced neurological maturity [7].

Pathophysiology: Both the physiology of structural and functional development need to be understood for a better understanding of neurological examination. Myelination begins in the brainstem around the 29th week of pregnancy and progresses cephalad (upwards) to the cerebral hemispheres by the 42nd week of pregnancy. Early myelination of the motor-sensory roots and the brainstem enables neonatal reflexes such as sucking and autonomic functions such as heart rate and respiration. The cephalocaudal tone progression is associated with increased myelination of subcortical motor circuits originating in the brainstem. Up to 40 weeks of caudocephalic flexor tone will be increased, and after that, the progression of extensor tone will occur in the cephalocaudal direction due to the maturation of modern cortical areas [7]. The passive tone is usually maintained by the brainstem. The active tone will change depending on the sleep state or the influence of the drugs. That is why only passive tone is used in the Ballard scoring system [7].

In preterm, the frontal lobe is a non-vital organ, which is why blood supply will go away to other lobes in low blood supply situations [8]. In the preterm watershed area, the periventricular area causes visual fibres and trunk fibres to be affected, which is why these babies are usually present with stiff legs and are unable to sit but can stand. In term babies, the parasagittal area will be affected, which is why the upper limbs and hip joint are more hypotonic [9]. The occipital lobe is usually affected by hypoglycemia due to deep sulci and gyri and a distant area of the posterior cerebral artery. It is important to note that when the middle cerebral artery is involved, it typically has no impact on the lower extremities.

In acute asphyxia, If the thalamus is injured, many dysfunctional outcomes will occur on follow-up with a normal neurological examination. The brainstem and upper part cause respiratory problems to occur. The lower part of the brainstem causes swallowing abnormalities. A mid-brain injury causes a pupillary problem. Even though the calcarine cortex is involved, they can see, but functional and field defects will be there. Functions usually develop in the order of touch, balance, taste, smell, hearing, and sight. As a rule, functional stimulation should be in the same order.

Neurological Examination: Newborns are usually tested on stage 4 of the Brazelton scale. Prechtl, 1982, described 5 stages: (1) “deep sleep,” (2) “light sleep,” (3) “quiet alert,” (4) “active alert,” and (5) “crying. He used these to differentiate between normal and abnormal babies. He mentioned these responses as spontaneous responses to stimuli. Brazelton and Nugent (1995) added the 3rd stage as drowsy [10].

Brazelton considers babies' capacity to control stimulus levels through the use of states of consciousness in adapting to their environment. In babies, autonomic, motor, organization of state, and responsiveness states will develop according to gestational age [10].

Extremely premature infants respond with changes in their vital signs as they are usually in an autonomic state. Babies usually change slowly from one state to the next. When the baby is sleeping, if we touch the baby, a motor wave comes from head to toe; if we repeatedly touch the baby before the completion of the motor wave, then the baby will wake up and come to the next stage. But in cases of severe asphyxia where the cortex is damaged, the baby will change from a sleeping state to a crying state rapidly [7].

Cortical Sensation: An irritable newborn becomes upset and cries in response to minor stimuli and cannot be soothed. Lethargic newborns are unable to pay attention. Habituation usually develops after approximately 30 weeks. Hearing habituation tests the temporal lobe function; sight habituation tests the occipital lobe; and touch habituation tests the parietal lobe. After the baby has been crying for 15 seconds, consolability assesses the overall cortex function. A cerebral-palsy child is usually resistant to consolability. Cuddliness also tests cortical function. Babies preferentially position their heads to the right because of the dominant left cerebrum [11].

Cranial nerve examination: As usual, the olfactory sensation is more primitive, which helps in breast crawling. It is usually tested by smelling any odour and observing the response of the face. It is usually present after 32 weeks but may vary as per the development of babies, as some babies, particularly IUGR babies, will have early neurological maturation. Vision usually develops late, and then continuously matures after birth. Preterm neonates are myopic, and term neonates are hypermetropic. Term infants possess the innate capability to concentrate solely on nearby objects, approximately 8–10 inches away from their faces, akin to the distance between a mother and her child held in her arms. They are also colour-blind; they prefer the human face. The menace reflex is more useful to test eyesight. At the time of elicitation of the menace reflex, don't push the hand suddenly because air will stimulate the cornea, which is supplied by the trigeminal nerve. The 3rd, 4th, and 6th nerves are usually tested by eyeball movements. In a severe case of hydrocephalus, the sunsetting sign and pressure on the longest 6th nerve will usually develop later because they have more space for expansion. When a baby is crying, the nasolabial fold's absence becomes more noticeable; hence, facial nerves are usually examined in this state. Forehead wrinkling is also better to observe to determine the upper motor neuron plasy. Nasolabial folds are preserved in cases of absent lingularioris muscles. Tongue symmetry and fasciculations usually test the hypoglossal nerve. The eighth nerve is usually tested in response to distal sound. The spinal accessory nerve is usually tested by the

prominence of the sternocleidomastoid muscle. Swallowing usually tests the fifth, seventh, glossopharyngeal, vagus, and hypoglossal nerves, but this reflex may develop late after 34 weeks. It is better to remember that reflexes can be accelerated up to some extent, particularly the swallowing reflex in preterms [12]. Though difficult, it is better to test every component of the mixed nerve.

Motor examination: Hypotonia is defined as decreased muscular resistance to passive stretching. Weakness is defined as a reduction in muscle power. The ability to apply force is defined as strength [13]. Hypotonia with normal strength will be present, like congenital hypotonia, but not vice versa. Posture, flexibility, passive tone, and active tone are typically used to measure tone. The heel-to-ear test, popliteal angle, scarf sign, and other methods are commonly used to assess passive tone. Active tone is usually tested when the baby is awake in supine, pull-to-sit, standing, and prone positions. In the pull-to-sit position, head lag indicates hypotonia. The stretch reflex in the shoulder girdle is triggered when holding the newborn with the arms extended. This makes it impossible to correctly interpret the active reaction at neck level in the pull-to-sit position. Holding the newborn at the shoulders is crucial to separate the axial activity of the trapezius, the primary neck extensor muscle. If we lift the hypotonic baby, it feels slippery. Maintaining the neonate in an upright sitting position while observing the drop of the head to the front or back is another frequent methodological error. Due to the weight of the head, this only permits the measurement of passive tone in the extensor and flexor muscles. Fallen limbs and head suspension in prone suspension indicate severe hypotonia. In severe chronic asphyxia due to a parasagittal injury, the upper limbs are hypotonic and extended, the hip joints are very loose. These babies may suddenly die after 72 hours due to maximum oedema at that time. That's why no prognosis is to be explained to the parents until 72 hours, since they may suddenly collapse. Hyperirritability and hypotonia on day 1 indicate mild hypoxia. Usually, ventral incurvation is greater than dorsal incurvation. In CNS abnormalities, dorsal curvature is greater than ventral. In hypotonia, both increased.

Fisting the cortical thumb, seen in chronic hypoxia due to parasagittal injury, usually involves the thumb because of the large representative in that area. In neonates, early writhing movements occur in the first 2 months. After 2-3 months, fidgety movements will appear [14]. The absence of these movements, particularly fidgity movements, indicates an early sign of cerebral palsy. Tendon reflexes develop early in the lower limb. They are difficult to elicit, particularly upper limb reflexes. The deep tendon reflex area is broader, so we can elicit the reflex by tapping a larger area rather than a precise area. A sustained clonus is abnormal. During the testing of passive tone, do not put your hands on the testing muscle and do not overstretch. But in the scraf sign demonstration, it is better to push the upper arm to avoid the effect of arm recoil. Any myoclonic jerks indicate structural changes in the infant brain. Isolated clonic seizures indicate intraventricular haemorrhage. In term babies, tonic seizures usually indicate increased intracranial pressure.

There are more than 200 neonatal reflexes, and they usually disappear as age increases because our neocortex usually suppresses these reflexes. All these reflexes are usually not centred in the spinal cord. It is in the brainstem and midbrain. That's why, unlike classical spinal reflexes, they will take time. Moro reflexes we will observe in monkeys. Moro reflex differentiates between asphyxia and kernicterus, as kernicterus babies show the threatening appearance of their faces. In the palmar grasp reflex, there is no role for the thumb, as the thumb is a more mature and mostly represented organ in the human cortex. The grasp reflex is present in Klumpke's palsy, whereas it is absent in Erb's palsy. We will observe crossed extensor reflexes due to a lack of precision. Amiel-Tison Neurological Assessment The examination will measure the passive and active tone at 40 weeks of gestational age. Training is not needed. The examination will be conducted in only 5 minutes. However, it has poor prediction unless combined with head ultrasound findings. This test can be done for up to 36 months [15]. The HINE (Hammersmith Neonatal and Infant Neurological Examinations) are simple, scoreable, standardized clinical neurological examinations for infants between 2 and 24 months of age [16].

Sensory system examination: The sensory systems are usually tested from head to toe with a cotton swab. In newborns, it is difficult to test the individual sensory dermatomes. However, specific and large sensory dermatomes can be tested. For example, when we touch the lateral side of the sole (S1), a Babinski reflex is triggered, and when we touch the medial side, a

grasp reflex is triggered (L5-S2). Deep pain causes structural and functional changes in the growing brain. Although premature babies feel more pain, they do not respond to it so we can check the response through vital signs [17].

2. CONCLUSION

Despite many advances, examinations of the nervous system are still mandatory. It plays an important role in the early detection of cerebral palsy. There are sufficient neurological scores that are clinically more precise. As plasticity decreases with age, early detection is necessary, which is usually possible through a thorough neurological examination.

CONSENT AND ETHICAL APPROVAL

It is not applicable.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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